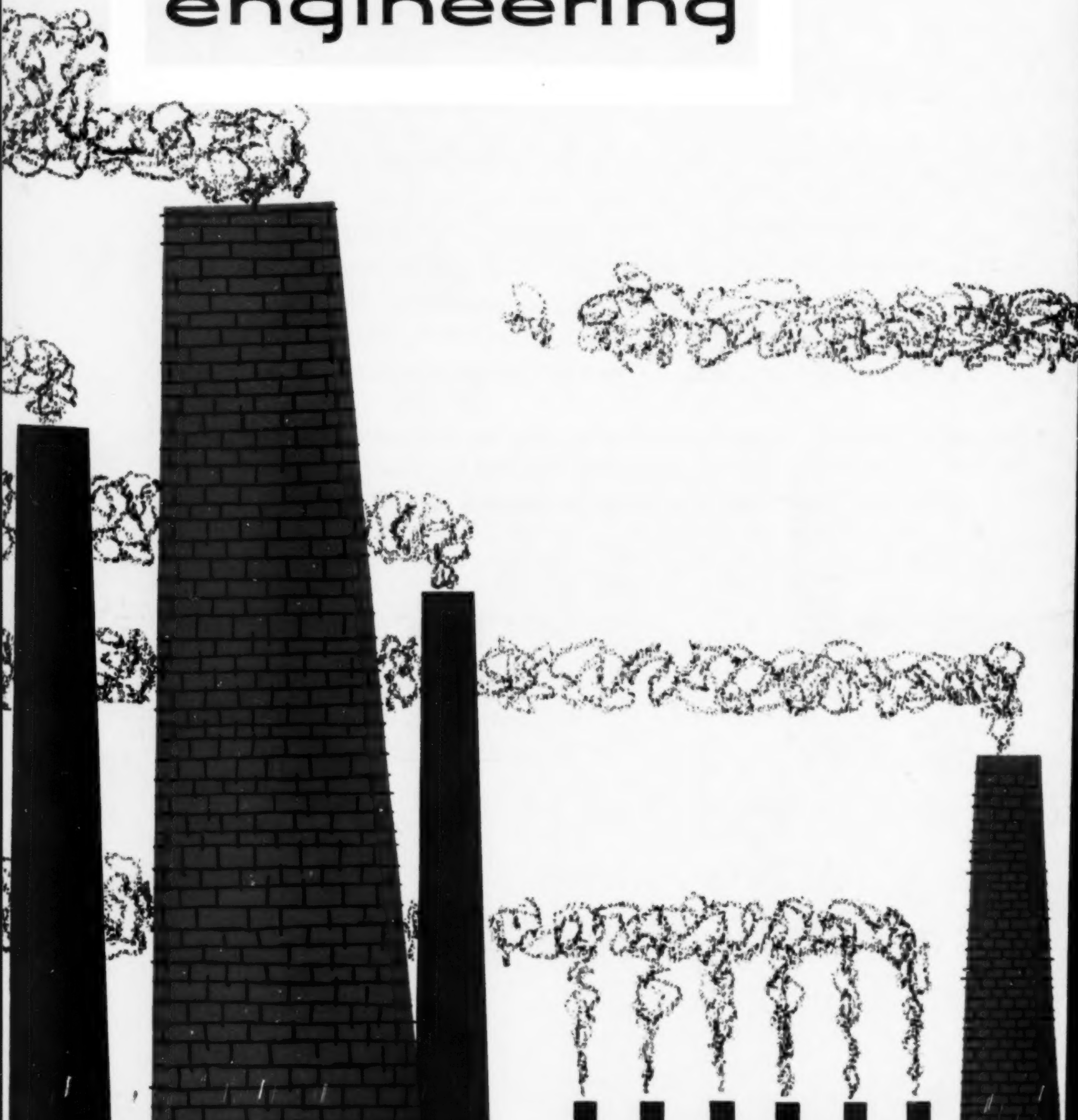
MINING engineering

NOVEMBER 1953



CF&I MINING OPERATIONS EXPANDED TO MATCH COMPANY GROWTH

MINING engineering

VOL. 5 NO. 11 NOVEMBER, 1953

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COVER

The furnace stacks on the cover this month are a reminder that growth and expansion of a company mean increasing dependence on the sources of raw materials. For the story of the part raw materials are playing in Colorado Fuel & Iron Corp.'s rise to ninth place in the ranks of the major steel companies, turn to the articles starting on p. 1084.

FEATURES

ARTICLES

TRANSACTIONS

— Personnel Service —

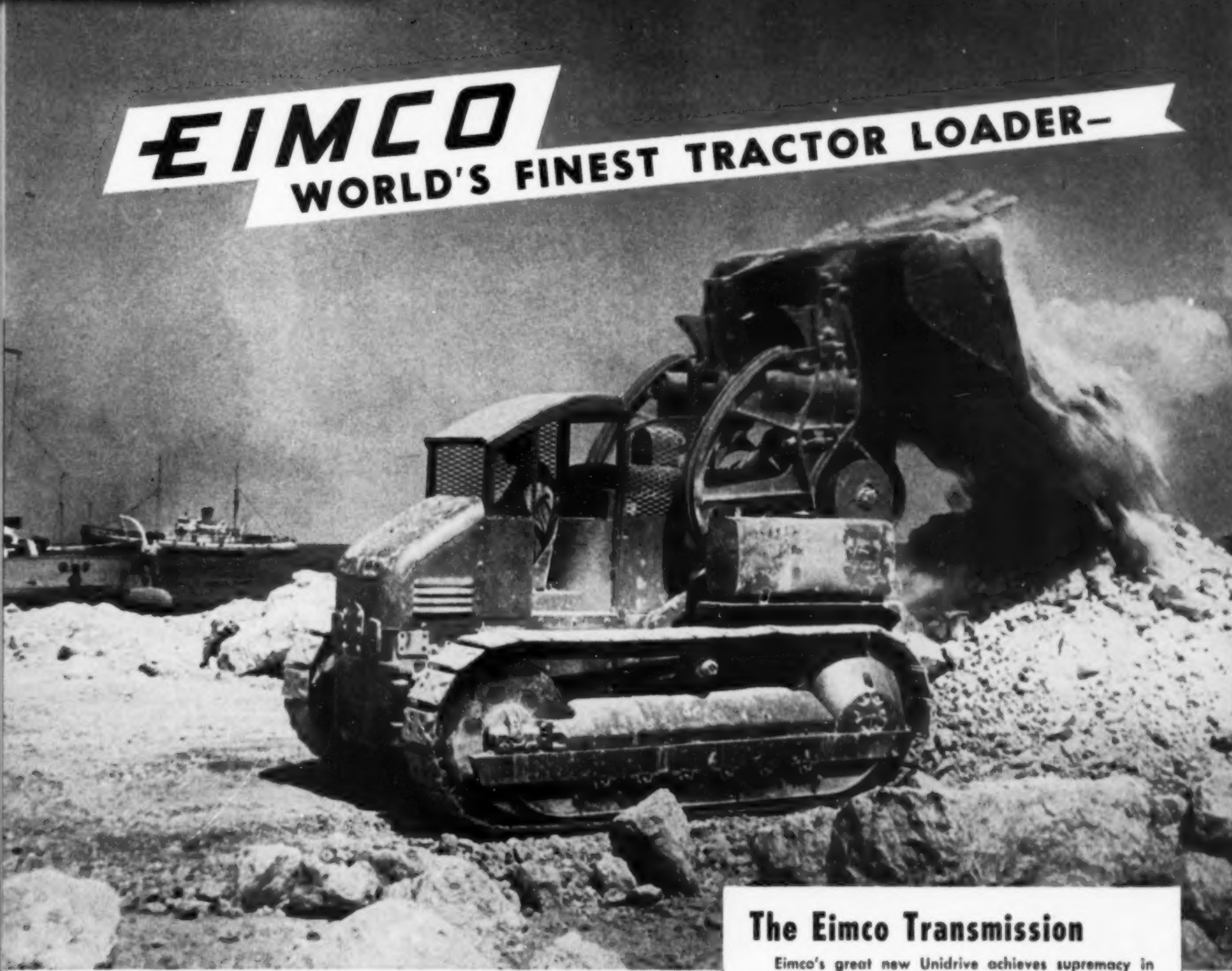
THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in cooperation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York office and include 6c in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service, to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter, $12 a year.

MEN AVAILABLE

Mining Engineer, 33, married. Nine years experience in mine operating, engineering, and development. Excellent production and labor relations record. Desires responsible position progressive mining company. Available reasonable notice. M-45.

Engineer, B.S. geology and mining, 40, married, two children. Sixteen years varied experience placer and hard rock mining, oil fields, civil engineering and construction in Latin America and Alaska. Speaks and reads Spanish and Portuguese. Desires employment Latin America, Canada or western U.S. Available reasonable notice. Employed. M-47.

(Continued on page 1054)



The Eimco Transmission

Eimco's great new Unidrive achieves supremacy in engineering advancement of tractor power transmissions.

The Unidrive is a compact transmission containing in one unit all of the gearing and clutches for speed changing and full independent reversal of each track. Its unique design combines all of the best features of torque converter, constant mesh gearing, hydraulically actuated friction clutches and sealed oil bath, pressure lubrication of all wearing parts.

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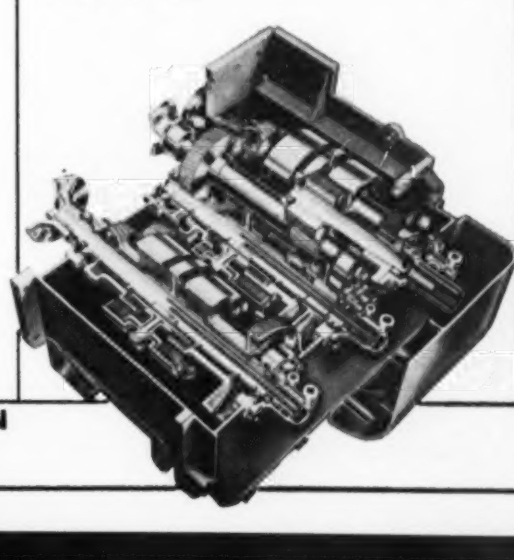

NEW—WITH MORE ADVANTAGES FOR YOU

Eimco's new 105 is the heavier, more versatile machine you've been looking for. The advantages of this machine over ordinary tractors are numerous, we mention a few here: Matched engine and torque convertor drive, new transmission (described at right), elimination of all foot clutches and manual gear shifting, immediate reversal in motion, speed changing under full power in motion, two speed discharge on loader, bucket capacity to 2½ cu. yds., all steel castings and many other features.

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A496

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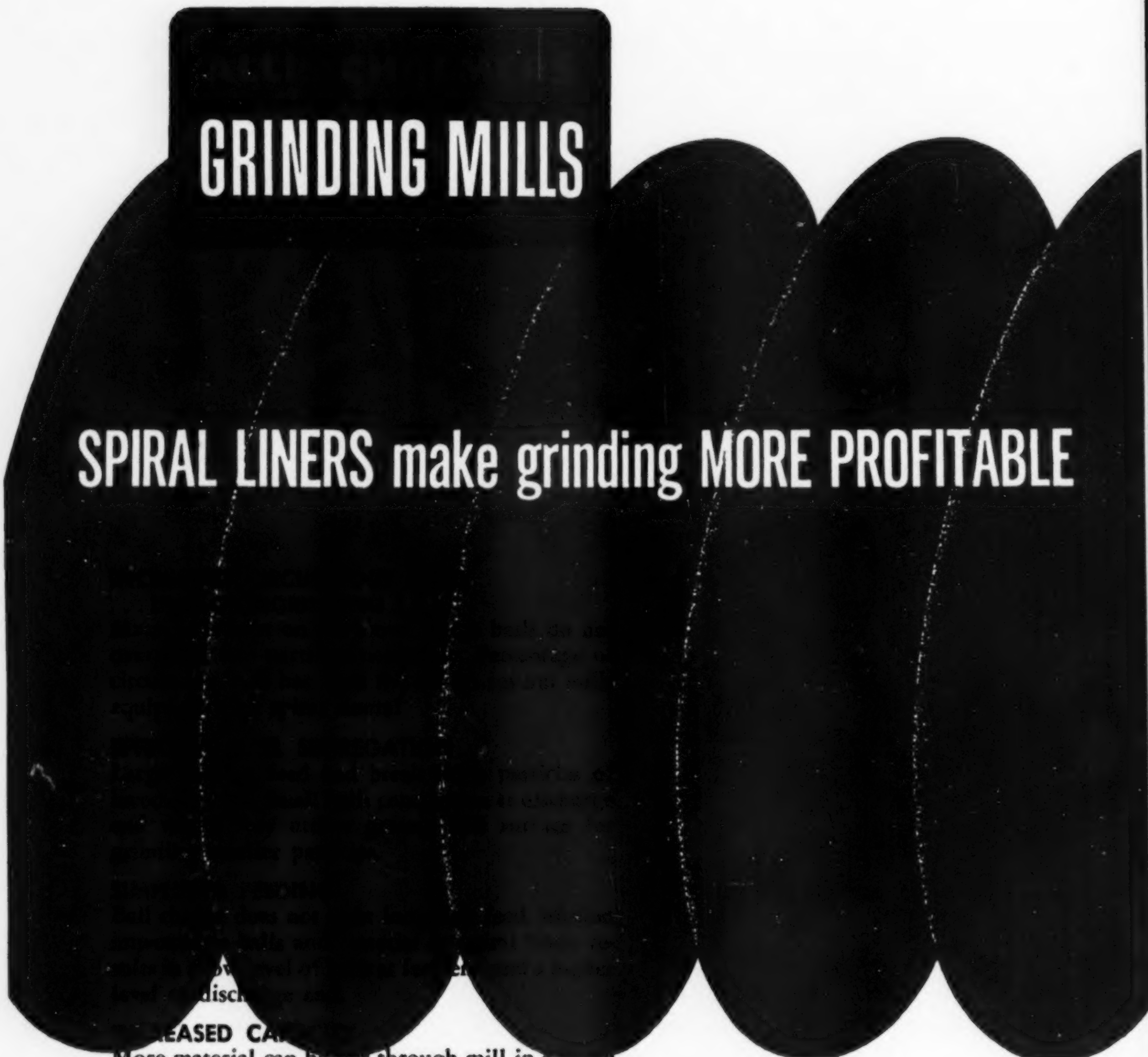

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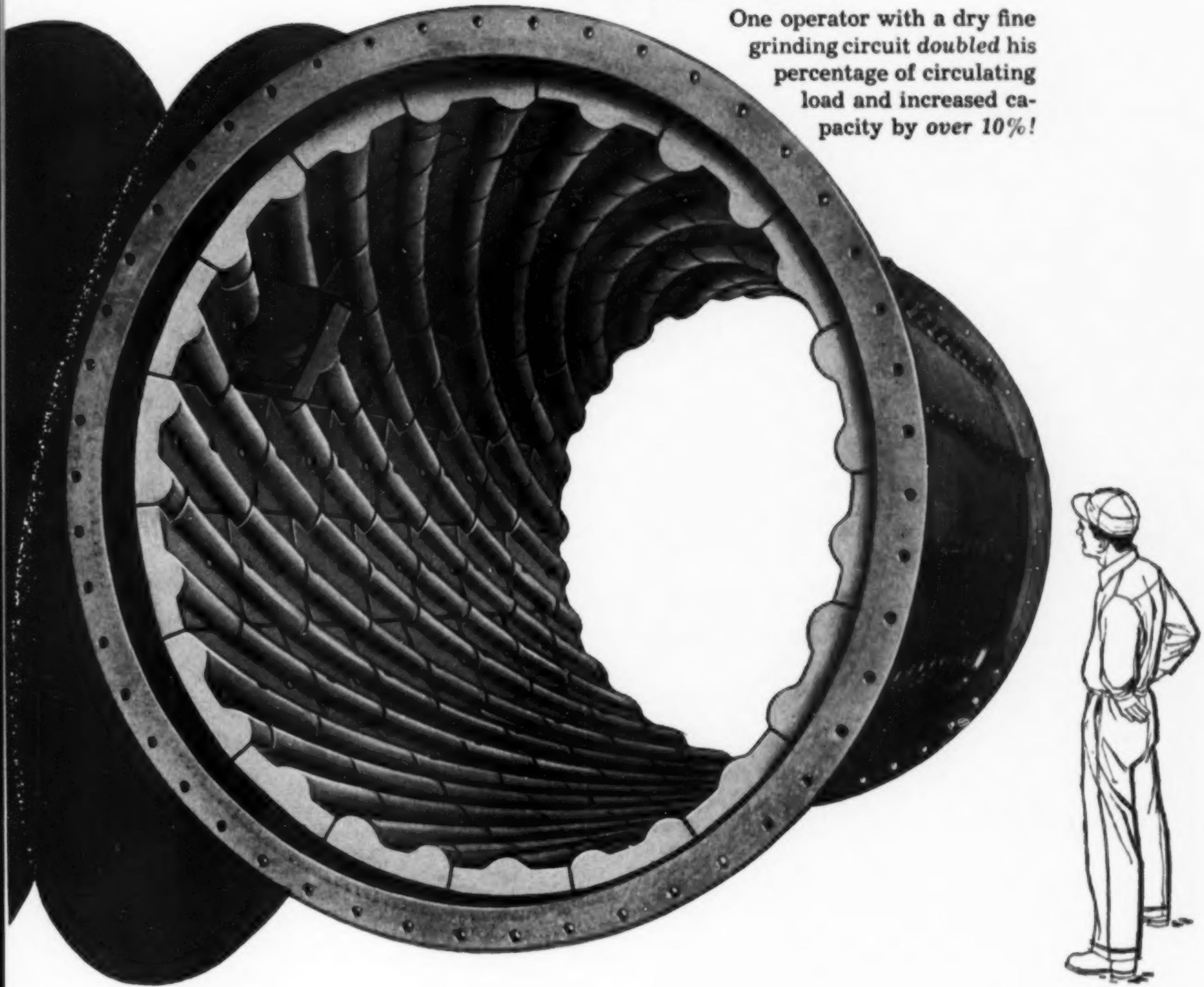

Personnel Service Cont'd

MEN AVAILABLE

Registered Mining Engineer, 37, married. Broad experience exploration and development of mineral deposits; and design and construction of metallurgical plants. Consulting geologist-geophysicist on hydroelectric projects, industrial and irrigation water supplies. Prefers project work on commission or contract. At present available. Will go anywhere, but prefers Denver. M-46-4010-E-5 San Francisco.

Mining Geologist, employed, 32, married, no children, Ph.D. Desires responsible position with mining company. Nine years experience covering research work, exploration in base metal districts applying aerial photography, in charge of geological department of operating mine, ore estimation, preparation of reports and maps on examinations. Will locate anywhere. M-44.

POSITIONS OPEN

Mining Engineer with dredging, milling, drying, and pelletizing experience for survey and report on iron ore project. Salary open. Location, U. S. and Canada. Y9175.

Recent Graduates, mining engineers, with one to three years experience in mining and milling for nonferrous operation. Salary open. Location, East and West. Y9159.

Engineers. (a) Mine Superintendent, 32 to 38, with ten years underground experience for deep mine. Excellent camp and living conditions. Must speak Spanish. Salary, $10,000 a year. (b) Assistant Mine Mechanical Superintendent, 40 to 50, with at least ten years experience covering installation and repair of compressors, pumps, hoists, and complete mining plant. Must speak Spanish. Salary, $10,000 a year. Location, Cuba. F9140.

Placer Development Engineer, 35-50, experienced in placer examination and operation of dragline dredges, hydraulics, sluicing, high lift pumping. Experience in reservoir construction and water distribution methods also needed. To be assistant to chief engineer. Three year contract. Salary, $8500 a year, tax exempt in U.S. currency. Quarters and living allowance. Location, Ethiopia. F9129.

Mining Engineer, 25 to 35, to sell coal mining equipment. Must have had at least five years experience in modern, underground coal mining, two years of which were in a supervisory capacity. Will make market survey and direct sales of this equipment. Sixty-day training period. About 50 pct of time traveling throughout eastern U.S. Headquarters, New Jersey. Y9096.

Mining Engineer for administrative position. Must have minimum of ten years experience in maintenance and construction work for mining operations. Salary, $15,000 to $18,000, depending upon experience and qualifications. Location, West. Y8941.

Mine Superintendent with 10 to 12 years underground experience for lead-zinc mine. Must speak Spanish. High altitude. Salary, $7200 a year plus housing and maintenance. Location, Peru. F9208.

Recent Graduates, mining engineers, with one to three years experience in mining and milling for nonferrous operation. Salary open. Y9159.

Assistant Mine Master Mechanic, 30 to 40, experienced in the maintenance of mine hoists, compressors, ventilating fans, pumps, etc., as well as operation of the mine shops. Salary to start, $6600 a year U.S. cur. Y8989(a).

Assayer to take charge of large laboratory. Should have had five to ten years experience in the assaying of precious metals. Salary open. Location, northern New Jersey. Y7929S.

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Letter to the Editor

Good, Clean Fun

Of recent months many articles have appeared in the technical journals and public press instigated by both the coal operators and by organized labor, agitating limitation on the importation of crude oil and residual fuel. It is claimed that such imports have reduced the domestic demand for coal and have been responsible for unemployment of miners. Actually, in spite of the rapidly increasing domestic demand for all types of fossil fuel (coal, oil, and gas), the production of coal dropped some 70 million tons in 1952, or roughly 12 pct over the preceding year. The increase in residual fuel import during the same period was equivalent to only 14 million tons of coal, so obviously the large drop in coal production cannot be attributed to petroleum importation. In fact, the percentage increase in oil imports was merely in line with the greater demand for energy as our population and standard of living increase. The reasons coal has fallen behind in the parade are due to high labor costs per unit output, dieselization of the railroads, conversion of home heating to gas and oil, and other factors of consumer preference and efficient utilization of energy.

Although up to now petroleum imports have had no direct influence upon coal production, the question might be raised as to whether the economy of the country would not be improved if imports were of sufficient volume to reduce very substantially the quantity mined annually of such a strategic resource as our domestic coal. Perhaps the use of coal should be restricted to the absolutely essential products such as metallurgical coke, chemicals, etc., with imported residual oil substituted for most power and heating purposes.

Such a policy would have two far-reaching economic consequences. It would offer several foreign regional areas the opportunity for receiving an honest income instead of a dole or unguaranteed loan from this country. With this dollar income, they would be able to purchase products manufactured in America, thus keeping up our factory employment and improving the standard of living of American labor. Offsetting the dollar loss of employment in our coal industry could be reduced taxes that would result from the fact that no longer would it be necessary to finance quite as many unsound foreign loans and defaults, as well as the many costly eleemosynary enterprises in the interest of international good will. Secondly, it would permit the Bureau of Mines and some of the more progressive coal operators to spend the next 25 years in developing coal research to a point where the products and their transportation could compete with petroleum in consumer satisfaction and efficient utilization. An excellent solution of government stock-piling, as far as energy is concerned, lies in sealed coal mines. These involve no steel tankage, the reserves are known, and they will be there for any emergency when technology or strategic warfare necessitates their development. Meanwhile—encourage coal research!

Signed:
A PHILOSOPHICALLY INCLINED PETROLEUM SCIENTIST

We wish to make clear that this letter does not necessarily reflect the editorial viewpoint of MINING ENGINEERING *or of the* AIME, *but rather it is published "all in the spirit of good clean fun," as its author wished. The author's name is on file, but his company affiliation prevents its publication.—Editor.*

Books for Engineers

ORDER YOUR BOOKS THROUGH AIME—Address Irene K. Sharp, Book Department. Ten per cent discount given whenever possible. Order Government publications direct from the agency concerned.

Brown Coal, Its Mining and Utilization, edited by P. L. Henderson, *Melbourne University Press;* New York: *Cambridge University Press,* $7.50, 351 pp., 1953.—Eleven postgraduate lectures delivered at the University of Melbourne, presenting extensive and detailed treatments of the nature and distribution of brown coal; briquetting; pressure gasification; gasification in fluid beds; etc. Well-illustrated.

Geology of the Johnston Grade Area, San Bernadino County, California, by Robert B. Guillou, *California Department of Natural Resources, Division of Mines,* Special Report 31, 75¢, 18 pp., 1 pl., 19 figs., 1953.—Thesis prepared in partial satisfaction of the requirements for the degree of Master of Arts, U.C.L.A.

Geological Investigations of Chromite in California, Bulletin 134, Part III—Sierra Nevada, Chapter 5, Chromite Deposits in the northern Sierra Nevada (Placer, Nevada, Sierra, Yuba, Butte, and Plumas Cys.), by Garn A. Rynearson, *California Department of Natural Resources, Division of Mines,* $2.00, 323 pp., 1953.—Written by a geologist with the U.S.G.S., this book has five maps in pocket, 17 tables, 10 figures.

Conveyor Terms and Definitions, *Conveyor Equipment Manuf. Assn.,* Washington, D. C., $1.00, revised edition, 1953.—Words such as grizzly, grasshopper, wishbone, mother are given their exact meaning for industrial specifications in this manual which lists 1500 terms and shows line drawings of more than 80 types of conveyors and parts.

Introduction to Engineering Economy, by Baldwin M. Woods and E. Paul De Garmo, *Macmillan Co.,* $6.00, 519 pp., second edition, 1953.—This textbook explains the relation of such subjects as accounting, valuation, investment theory, statistical methods to the management of engineering enterprises.

Symposium on Exchange Phenomena In Soils (Special Technical Publication No. 142), *American Society for Testing Materials,* Philadelphia, $1.75, 74 pp., 1953.—Five articles are included on the related aspects of this field of soil physico-chemistry. They deal with basic phenomena leading to methods by which soils are altered to achieve adequate engineering performance even under adverse circumstances. Both generalities and specific data are provided.

The History of Fifty Years of Mining at Tonopah, 1900-1950, by Jay A. Carpenter, Russell Richard Elliott, and Byrd Fanita Wall Sawyer, University of Nevada Bulletin, *Nevada Bureau of Mines,* $1.00, 157 pp., 1953. —This bulletin is published at a particularly appropriate time, Vernon E. Scheid writes in his foreword, as recent exploration renews hopes that Tonopah may have a revival. Eleven photographs, one map.

The Geology of Henrys Chapel Quadrangle, Northeastern Cherokee County, Texas, by H. B. Stenzel, *Bureau of Economic Geology,* University of Texas, $3.50 paperbound, 118 pp., 1953.—This paper has a geologic map in colors, 57 text figures, including many profiles and detailed sections of the Newby member of the Reklaw formation.

Correlation Between Surface and Subsurface Sections of the Ellenburger Group of Texas, by Leo Hendricks, *Bureau of Economic Geology,* University of Texas, $2.50 paperbound, 44 pp., 1953.—The sample characteristics of the formations in this group recognized from a study of sampled sections are outlined, and a systematic discussion of residues is included. One text figure, six plates.

Evolution of the California Landscape, *California Department of Natural Resources, Division of Mines,* Bulletin 158, $2.50, 240 pp., 1952.—Profusely illustrated description of the state's diversified landscape and surface features in terms of geologic and rock structures. Three maps.

Coal Production in the U. S. A., by Companies for the Year 1952 *McGraw-Hill Publishing Co.,* $5.00, 40 pp.—Tonnages of all U. S. coal operating companies producing 100,000 tons or over in 1952. Companies listed according to affiliation, production, and state. Strip and captive production shown.

California Journal of Mines and Geology, *California Dept. of Natural Resources, Div. of Mines,* $1.00, 74 pp., Vol. 49, No. 3, July 1953.—This volume contains *Flotative Properties of Titanium Minerals in Oleate Solutions,* by V. S. Pradhan and D. W. Mitchell, a paper on Kings County resources, and one on adsorbent clays in California. Four photos, two pocket maps.

A Practical Chromatography, by R. C. Brimley and F. C. Barrett, *Reinhold Publishing Corp.,* $5.00, 128 pp., 1953.—The techniques of paper, adsorption, partition, and ion-exchange forms of chromatography. Equipment used is analyzed and practical application of the methods in the analysis of precious metals is indicated.

Pumps, Types, Selection, Installation, Operation, and Maintenance, by Frank A. Kristal and F. A. Annett, *McGraw-Hill Book Co. Inc.,* $6.50, 373 pp., second edition, 1953.—This standard text provides a comprehensive, practical study of available types of pumps covering a wide range of applications: boiler-feed, deep-well, sewage and sludge, chemicals, etc. Major additions occur in the material on diaphragm pumps, rotary pumps, and jet pumps.

U. S. Bureau of Mines Publications

RI 4942 Synthetic liquid fuels. Part I. Oil from Coal.

RI 4943 Synthetic liquid fuels. Part II. Oils from oil shale.

RI 4948 Bull Valley iron-ore deposits, Washington Cy., Utah.

RI 4953 Lead-Zinc deposits, Harrington-Hickory mine, Beaver Cy., Utah.

RI 4955 Thermodynamic properties of sodium and potassium-aluminum silicates.

RI 4962 Blasting no-cut-hole raise rounds using millisecond delays.

RI 4964 Washability study of Upper Hartshorne coal bed, Quality mine, Hackett, Ark.

RI 4956 Blasting research at Bureau of Mines oil-shale mine.

RI 4967 Use of torque wrench to determine load in roof bolts. Part 1. Slotted-type bolts.

RI 4968 Determination of moisture-holding capacity of coal for classification by rank.

RI 4969 Determination of moisture in low-rank coals.

RI 4974 Analyses of formation brines in Kansas.

RI 4818 Taconite fragmentation. Tests to develop more efficient blasting methods.

RI 4978 Anthracite mechanical mining investigations. Progress Report 6. Brieden pneumatic packing machine.

RI 4979 Manganese investigation, Scallon-Todd lease, Aitkin Cy., Minn.

RI 4980 Mine timber preservation by collar method. Progress Report 1. Injection of chromated zinc chloride.

RI 4981 Red iron ore, Woodstock and Bucksville areas, Alabama.

RI 4984 Concentration of Klukwan, Alaska, magnetite ore.

RI 4985 Concentration tests of manganese ores from California, Nevada, and Mexico.

RI 4989 Investigation, Sunset copper mine, Snohomish Cy., Wash.

RI 4990 Colorimetic method for determining pine oil in water.

IC 7656 Improving coal-mine ventilation.

IC 7660 Convertol process of coal-slurry treatment.

IC 7662 Fire-fighting equipment in coal mines.

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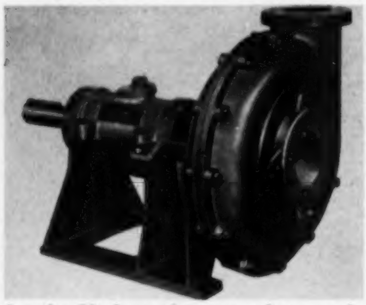
Manufacturers News

Centriseal Pump

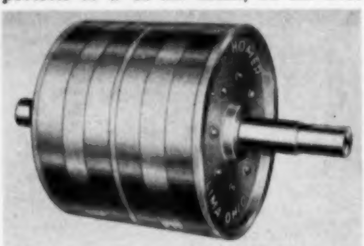
The Centriseal pump, which operates entirely without sealing water, has been developed by the *Allen-Sherman-Hoff Pump Co.* to handle abrasive or corrosive solutions that must be delivered undiluted. Beside meeting restrictions on dilution, the new pump is the A-S-H substitute



for the Hydroseal pump where sealing water is unavailable. Pumping parts are protected by molded Maximix rubber, and tailor-made alloy parts are available for installations handling acids. Mechanical parts of the Centriseal interchange with those of antifriction bearing type Hydroseal pumps. **Circle No. 1.**

Permanent Magnet Pulley

Homer Mfg. Co. announced completion of a 42-in. diam, 36-in. belt



width Alnico magnet pulley for installation at the Alcoa plant in Mobile, Ala. Used in handling bauxite ore, pulley is one of world's largest. **Circle No. 2.**

Smokescope

An advance model of the Smokescope, new instrument for indicating density of smoke in stack effluent, was demonstrated by the *Mine Safety Appliances Co.* The portable instrument eliminates interference by stray light and provides a projected reference standard for visual comparison. **Circle No. 3.**

Service Training School

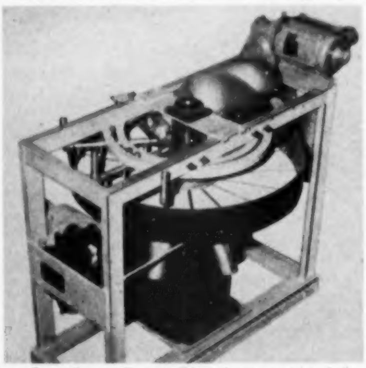
Euclid Road Machinery Co. has issued details of its school for service training. Specialized courses aimed for dealer and customer personnel provide training in operation and maintenance of heavy duty earth moving equipment. **Circle No. 4.**

Superdip Compass

Originally conceived by Dr. W. O. Hotchkiss, developed by Dr. N. H. Stearn, and widely used for exploration and prospecting, the Hotchkiss Superdip is on the market after an absence of ten years. *Ruska Instrument Corp.*, in cooperation with Prof. W. A. Longacre of Michigan College of Mining and Technology, has redesigned the instrument to decrease its weight, simplify operation, and increase accuracy. Used as either a total intensity magnetometer or a vertical intensity magnetometer, the new Ruska Superdip has a temperature compensated needle system. Weight has been reduced to 10.5 lb without case. **Circle No. 5.**

Horizontal Vacuum Filter

The FEinc horizontal rotary vacuum filter is stated to offer high capacity, fast dewatering, and excellent cake washing for filtering coarse crystalline materials, fibrous pulps,



and other free filtering materials. The new design featuring a protected, central-mounted drive is illustrated in the 3-ft diam size. Larger units up to 110 sq ft are also available from *Filtration Engineers Inc.* **Circle No. 6.**

Easy Marking

Marking trees, railroad ties, steel, or establishing sighting points can be made easier with a new paint-can-gun combination offered by the *Nelson Co.* The disposable paint can, which attaches to the self-cleaning sprayer, supplies a special, highly visible marking paint, available in several colors. **Circle No. 7.**

Company Announcements

Linatex Corp. of America has appointed *Toncray Equipment Co.* of Denver to handle sales, fabrication, and application of Linatex in that area . . . *Central Mine Supply Co.* has added a new department to manufacture hose couplings and assemblies . . . *Allis-Chalmers Mfg. Co.* expects that transfer to it of the assets of the *Buda Co.* will be completed shortly.

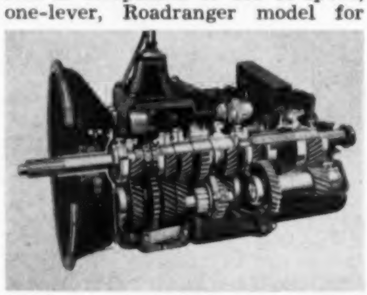
Small Cyclone

The multiple unit TM DorrClone for fine sizing of clays, starch, fillers, and pigments is said to be capable of separations in the 2 to 20 micron range. Consisting of a number of small cyclones in a common housing, the unit is said to eliminate need for

a centrifuge in many cases, and produces comparable results with greater control and flexibility than now possible. The machine is built by *The Dorr Co.* in nests containing 24 rubber cyclones 15mm diam, or 32 bakelite cyclones of 10mm diam each. Individual units, similar to the larger DorrClones, have a common central feed chamber, and the underflows and overflow are each combined prior to discharge. **Circle No. 8.**

No Gear-Splitting

Drivers of trucks in the 125 to 160 hp class are now able to utilize eight speeds forward with "one stick—no gear-splitting transmission" introduced by *Fuller Mfg. Co.* This 8-speed Roadranger transmission is companion to the 10-speed, one-lever, Roadranger model for



trucks up to 300 hp or 800 lb-ft torque. The eight forward speeds are obtained by using a 4-speed shifting pattern twice, first with the auxiliary section in low range, then with it in high range. A push button handles the power shift from low to high range. **Circle No. 9.**

Cable Reel

The Tournarope bantam cable reel for dozer use, designed to eliminate waste of large quantities of wire rope due to wearing out of small sections, is built by *LeTourneau-Westinghouse Co.* **Circle No. 10.**

Free Literature

(11) HEAVY-MEDIA SEPARATION: Latest issue of Mineral Dressing Notes published by the *American Cyanamid Co.* is new 1953 edition of "Heavy-Media Separation Processes for Mineral Concentration." New edition keeps pace with tremendous increase in number and variety of H-M applications and discusses recent changes in medium and separation technique.

(12) PACKINGS: The mechanical goods division of *U. S. Rubber Co.* has issued a 112-page catalog on the proper selection, installation, and care of packings. A 4-page index provides a handy reference to metric engineering tables, temperature conversion charts, chemical resistance on gasket materials, tables on melting points, etc.

(13) MODERN MEASUREMENTS: Over 37 different instruments, especially engineered and produced for electrical, physical, resistance-welding, and electro-acoustical measurements, etc., are illustrated and described in the 34-page book published in two colors by *Brush Electronics Co.*

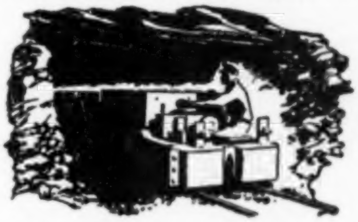
(14) LIGHTING STANDARDS: Completely revised edition of RLM Standards Specifications book by the *RLM Standards Institute* offers latest approved industrial lighting specifications for utilization and light distribution.

(15) ELECTRIC SHOVEL: *Marion Power Shovel Co.* has bulletin describing the Marion 111-M Ward-Leonard electric shovel with a standard 4-yd dipper or bucket. It is featured as shovel, dragline, crane, clamshell, and coal loader. Dragline capacity varies from 3 to 4½ cu yd depending on boom length and crane capacity is 165 tons.

(16) GRAPHIC CONTROL: Panelgraph central control panel which utilizes visual aid techniques to present process information to the operator is covered in bulletin from *Panellit Inc.* Typical applications and techniques of graphic symbolism are illustrated.

(17) ELECTRODES: A 50-page pocket guide to Airco electrodes issued by *Air Reduction Sales Co.* gives chemical analysis, welding and application procedure for 30 different electrodes.

(18) BATTERIES: In 1890 the first important use of the products of *The Electric Storage Battery Co.* was to enable pioneer lighting companies to



provide continuous service—24 hr a day. An attractive booklet shows the research and engineering involved in making Exide batteries for today and tomorrow.

(19) ROCK BOLTS: Blasting has little or no effect on *Colorado Fuel and Iron Corp.'s* rock bolts. Further information is available on how to provide greater safety and economy, and improve ventilation by eliminating crossbars and posts with roof and wall boltings.

(20) FLOWRATOR METERS: Catalog from *Fischer & Porter Co.* is an "introduction to Flowrator meters for flow rate measurement of liquids and gases by the variable area method."

(21) NEW QUARTERLY: In addition to "Blue Brute News" and "Climate Chart," which cover the construction and air conditioning fields, *Worthington Corp.* announces "Power and Fluids," to be issued four times a year. Its editorial content will be slanted to serve as a technical aid to readers in the power and fluid handling fields.

(22) EXPLOSIVES: Specific aid in the selection of industrial explosives for underground and strip mining, quarrying and construction, seismic prospecting, pipeline, and oil field work, is offered in a 48-page book from *Atlas Powder Co.* Included is a section on the Rockmaster (millisecond delay) system of blasting.

(23) POWER TRANSMISSION: Catalog 400 from *The Cleveland Worm & Gear Co.*, manufacturers of worm gearing and worm gear speed reducers, presents information on solving power transmission problems.

(24) FIRING CABLE: Noncracking over a wide temperature range, flame retarding and waterproof, with an exclusive Chester nylon jacket over center core to increase service life and promote mine safety are some of the features of the shot firing cable made by *Chester Cable Co.* Complete information is available on this cable, and on telephone wire for rugged installations and on new improved blasting wire.

(25) EMERGENCY POWER: *Homelite Corp.'s* portable generators supply emergency electric power when storms, fires, floods, or accidents disrupt normal power supply. A 4-page catalog explains various uses of these compact, lightweight, gasoline-engine-driven generators for industry, homes, institutions, etc.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after February 15, 1954—if mailed in U. S. or Canada

Please send me { More Information ☐ / Free Literature ☐ / Price Data ☐ } on items circled.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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61	Students are requested to write direct to the manufacturer.								

Name__________ Title__________

Company__________

Street__________

City and Zone__________ State__________

(26) REUSABLE RACKS: A folder from *M-H Standard Co.* describes Versabar. This structural steel member requires only a wrench and a hacksaw to assemble, yet racks made with it are claimed to have the strength of welded units and to be 100 pct reusable.

(27) DRILLS: *E. J. Longyear Co.'s* diamond core drills are "used from the frozen Arctic to sweltering Africa, wherever the going's toughest." A general bulletin shows their wide

choice of models, capacities, and power units.

(28) BULB CHANGERS: Light bulbs high above the floor can now be changed with ease and safety. So says *J. B. Sebrell Corp.*, makers of lightweight aluminum poles in various lengths that have detachable bulb changers in different shapes.

(29) SIEVE TESTER: *W. S. Tyler Co.* has a booklet on the Ro-Tap sieve shaker. Each movement of the Ro-Tap is mechanically controlled so as to be absolutely alike in every test, thus eliminating the errors of shaking sieves by hand. While the machine is doing the sieving, the operator is free for other work. The Tyler Timer stops the Ro-Tap at the end of a predetermined period.

(30) INDUSTRIAL ENGINEERING: Manufacturing, engineering, and construction of plants, special machines, and industrial furnaces, ovens, and dryers are covered in General Catalogue No. 127 from *Continental Industrial Engineering.*

(31) HAND TROLLEYS: Of interest to companies requiring a mechanical method of handling products intermittently where the cost of a power driven trolley conveyor would not be justified is *Jervis B. Webb Co.'s* catalog on hand pushed trolleys, cranes, and switches.

(32) ADHESIVES: A bulletin from *Monsanto Chemical Co.'s* Phosphate Div. contains information obtained from application research in the field of using polyurethanes as adhesives for bonding rigid materials, such as metal-to-metal or glass-to-glass.

(33) WEIGHING SYSTEMS: Data sheet describes electronic scale and printer manufactured by *Gilmore Industries*, used in the steel, chemical and manufacturing industries for crane, conveyor, platform, hopper, or tank weighing. Sheet also describes Gilmore electronic scale for monorail and floor-operated cranes, and Brown servo components utilized in these systems.

(34) LIGHT MEASUREMENTS: *Hunter Associates Laboratory* was established to meet the need of busy chemists, engineers, and executives for a source of information and data on the photometric properties of their products. A circular describes the techniques of this new laboratory.

(35) PIPE COUPLING: Folder from *Morris Coupling & Clamp Co.* explains use of the coupling on cast-iron, steel, and asbestos-cement, threaded or mechanical joint. Photo legend shows speedy method of on-the-job assembly.

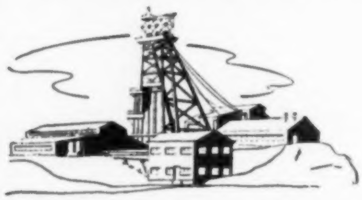
(36) ROASTING: "FluoSolids Roasting of Zinc Concentrates" introduces zinc producers to a new method of roasting zinc concentrates utilizing the principle of fluidization. This, *The Dorr Co.* leaflet states, "represents a development of major significance, and has been definitely proven to produce both a better calcine and a stronger gas."

(37) V-BELTS: A 52-page technical manual on V-belt drives, with tables, graphs, and diagrams, issued by *Boston Woven Hose & Rubber Co.*, covers such subjects as How to Select a V-Belt Drive, V-Belt Drive Design Sheet, Speed Up Drives, etc.

(38) RAYON BELTING: *Goodyear Tire & Rubber Co.'s* 4-page brochure, A5163K, illustrates and describes Thor rayon transmission belting, claimed to be far superior to similar belting manufactured with cotton plies.

(39) CENTRALIZED LUBRICATION: *Farval Corp.* has a new 20-page illustrated bulletin, No. 26. Photographs are retouched to show Farval centralized systems of lubrication in use on a milling machine, open hearth hot metal crane, etc.

(40) CENTRIFUGAL PUMPS: *Ingersoll-Rand* has an 18-page, 3-color bulletin on the class CNTA multistage centrifugal pumps. These units,



specifically designed for boiler feed, refinery, process work, and mine pumping services, are available for all service from 300 to 1000 psi with capacities to 700 gpm.

(41) TESTING INSTRUMENTS: *General Electric Co.* has announced a buyer's guide on electric testing instruments. This 16-page bulletin, GEA-5469B, provides data on such instruments as hook-on power-factor meters, portable recorders, insulation-resistance meters, etc.

(42) SPANISH TRANSLATION: The "Stoody Guidebook" has been translated into Spanish. Published by the *Stoody Co.*, manufacturers of hard-facing alloys, the book duplicates the material covered by the English edition. Described and illustrated are more than 100 ordinary uses of hard-facing alloys in maintenance of heavy equipment used in mining, earthmoving, cement plants, rock products, and clay plants.

(43) AIR CONDITIONING: Bulletin 600 describes Staynew ventilation and air conditioning filters, made by the *Dollinger Corp.* Also listed are specifications, engineering and performance data for panel filters.

(44) RESEARCH REVIEW: Available from the *American Society for Testing Materials* are reprinted copies of the "Review of ASTM Research," a 22-page pamphlet summarizing the work of various technical committees of the Society as of May 1953.

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DEEP HOLE DRILL—The NEW SFH99—with Gardner-Denver Sectional Rods—permits a 4' change when ring drilling from a 7' drift.
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THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS FOR CONSTRUCTION, MINING, PETROLEUM AND GENERAL INDUSTRY

A

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(A) **Ni-Hard Liners in Rod Mill** . . . still good after grinding some 2,500,000 tons of iron ore in approximately 3 years.

(B) **Ni-Hard Fan Liners** . . . for sintering plant blower system served at least 2 years. Those of steel lasted 2 to 3 months.

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Ni-Hard Rollers . . . installed on tailing conveyor in 1948, and still operating. Steel rollers lasted about 6 months.

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. . . by using Ni-Hard to curb abrasion

It will pay you to investigate the performance of "NI-HARD®", a nickel-chromium white iron, the most abrasion resistant product of the iron foundry.

The structure of Ni-Hard is as hard as that of fully hardened steel. *As a result of its unusual structure, Ni-Hard provides abrasion resistance at lowest ultimate cost.*

The illustrations show Ni-Hard applications that are saving *money, time* and *labor* for an Adirondack iron mine. All were cast by the Plattsburg Foundry and Machine Company of Plattsburg, N. Y.

Produced under foundry controls to meet INCO's high specifications, Ni-Hard is obtainable from authorized foundries, coast to coast, in all shapes common to the iron foundry industry.

Make use of our 20 years' practical experience in the Ni-Hard field to determine how Ni-Hard *will stand the gaff* on your particular applications. Get full details... use the coupon now.

Ni-Hard Liners on Steel Trough . . . still useful after more than 7 years of service . . . replaced rubber liners which lasted about 1 year.

Ni-Hard Plates Comprise Swinging Spout . . . used for feeding mixture of concentrate and coal to sintering machine. Steel plates formerly used, lasted 1 to 3 months. Average life of Ni-Hard plates: 13 months.

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EMBLEM OF INCO SERVICE

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

Market experts note that the strike at Chuquicamata copper mine in Chile has had little or no effect on the price of copper. Reason is that Chilean copper was piling up at shipping points while Chile argued for a 36½¢ price. Users seemed to find that they could get along without Chilean copper. In fact, the Wall Street Journal expects further decline in the copper price, already well below Chile's price demands. Producers and consumers alike feel that the tightened supply brought about by strikes in U. S. and Canadian mines will ease soon, and users are buying only for current needs.

Pittsburgh Consolidation Coal Co. announced purchase of the Weirton mine, near Morgantown, W. Va., from National Steel Corp. for $1.5 million. Pittsburgh does not plan to reopen the mine. Equipment will be transferred to other Pittsburgh mining operations.

Western mining activity is on the decline, according to Raymond B. Holbrook, attorney for U. S. Smelting Refining & Mining Co. In a report on the hard minerals industry, he said: "In 1935, there were 11,181 producing nonferrous mines in the western United States, and by 1950 only 1,847 were in operation. Today those operating on a commercial basis could be numbered in three figures."

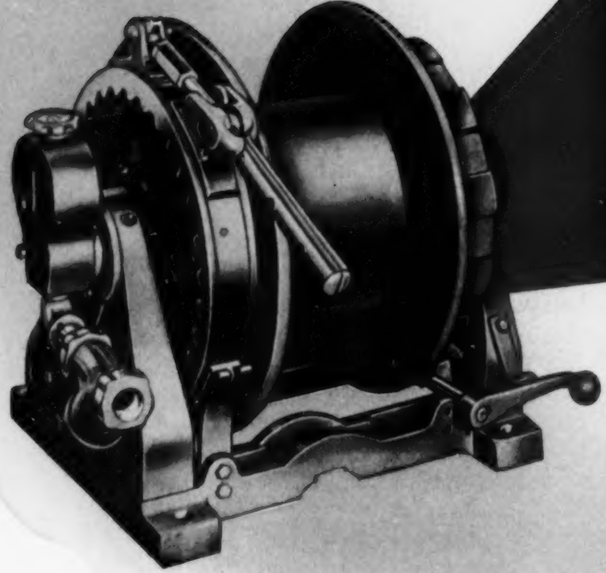
A field survey party of the Geological Survey of Canada has discovered an occurrence of scheelite in Newfoundland on a concession held by the Newfoundland & Labrador Corp. A representative sample of one of three concentrations contained a relatively high percentage of scheelite.

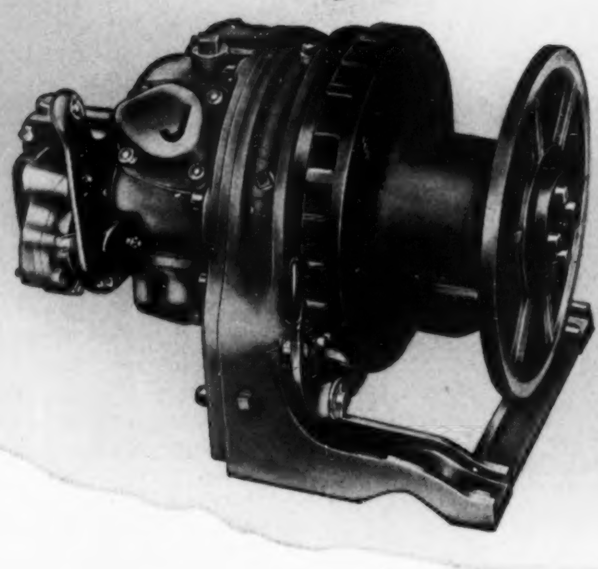
Vanadium Corp. of America has started operation of a roaster for ore bearing uranium and vanadium at its Naturita, Colo., mill. Construction of the roaster took 80 days by the company's 120 employees at Naturita. It is the third installation at the mill and increased mill capacity by 80 pct.

Preliminary examination of the Congressional appropriations for fiscal year 1954 discloses that the Geological Survey budget will be increased only 9.4 pct in comparison to 1953. The Geological Survey figure for 1954 is $27.75 million, while in 1953 it was $25.36 million. National Bureau of Standards is the hardest hit in the economy wave with a cut of 22.4 pct in its appropriation.

J. J. Forbes remains as director of the Bureau of Mines until he retires, Nov. 11, 1955. Decision to retain Forbes followed a conference of Interior Undersecretary Tudor, Harry M. Moses of the Bituminous Coal Operators Assn., Interior Secretary McKay, and Assistant Secretary Wormser.

You'll get JOY





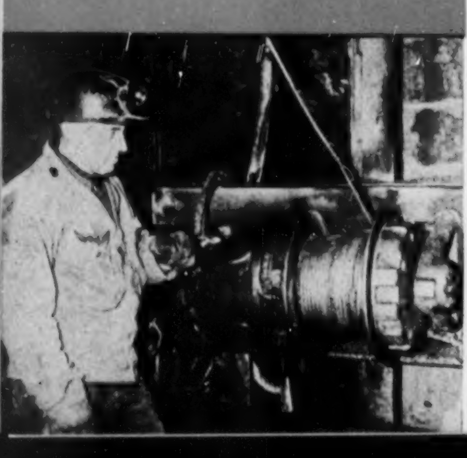
TOP: Model F-113 "Turbinair". Compact, simple design with motor *inside* the drum. Direct power transmission from motor to drum assures maximum efficiency. Simple, accessible controls make operation easy.

RIGHT: Model DW-111 "Pistonair". Features reversible power with light weight. Four-cylinder, 3½ h.p., reversible motor will handle up to 1200 lbs.

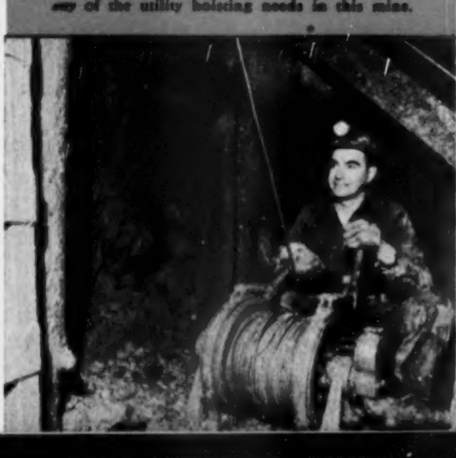
FAR RIGHT: Model L-111 "Pistonair". For heavy hoisting jobs. 7½ h.p., reversible, five-cylinder motor for loads up to 2000 lbs.

OVER 100 YEARS OF ENGINEERING LEADERSHIP

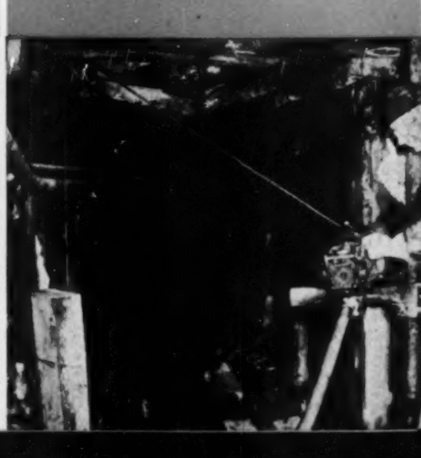
Joy L-111 reversible "Pistonair" Single Drum Hoist operating in a magnetite iron mine in the Adirondack region of New York.



Joy B-112 "Turbinair" lifting timbers in a raise in a western mine. The extra rope capacity of the B-112 (450' of ⅝" rope) makes it applicable to *any* of the utility hoisting needs in this mine.



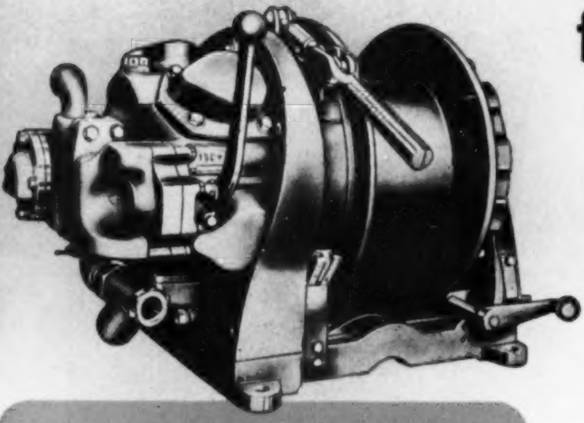
Joy AW-80 Air Winch hoisting timbers into place in a drift in a Canadian mine. At a weight of only 85 lbs., this unit will lift 500 *lbs!*



BETTER SERVICE from

SINGLE DRUM HOISTS

They're real Mining Hoists— designed and built from long field experience expressly for underground use



Joy Single Drum Mining Hoists are compactly designed, of modern, high-strength alloy metals, for lighter weight with greater power and efficiency.

The complete Joy line includes the "Turbinair" series which develop maximum horsepower per unit of weight; the "Pistonair" with reversible four or five cylinder motors; and compact, rugged electric-powered models which feature space-saving short-length external motors.

Joy Single Drum Hoists are built with lifting capacities ranging from 500 to 3500 lbs., and rope capacities from 150 to 1500 ft. "Pistonair" models have a positive acting safety brake which holds the load in any position when the throttle valve is "off."

Joy also manufactures a complete line of Shaft Hoists, and Two- and Three-Drum Slusher Hoists in capacities to handle all hoisting and scraping needs.

Have you seen this film?

"HARD ROCK MECHANIZED MINING"

16 mm-Sound and Full Color-40 Minutes

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Address our Film Booking Office.

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Phosphate Rock Output Increases

Phosphate rock production in the U. S. rose to 12 million long tons, according to the Bureau of Mines, for a record high.

Actual mine production of phosphate ore in 1952 was 32.8 million long tons. The Bureau of Mines noted that in previous years production of phosphate rock was recorded as mine production. In reality, it was a composite of salable products from washers and concentrators of Florida hard rock, Florida land pebble, and Tennessee brown rock; drier production of Florida soft rock; mine output of Western rock plus tonnages of Florida land pebble and Tennessee brown rock ore used directly.

Establish Minerals Advisory Committee

An advisory committee for the formation of policy on mineral development and exploration has been established by the National Science Foundation. James Boyd, Kennecott Copper Corp., and former director of the Bureau of Mines, has been named chairman.

A panel, appointed last year to review proposals of the President's Materials Policy Commission on an extensive program of mineral development, recommended establishment of the advisory committee.

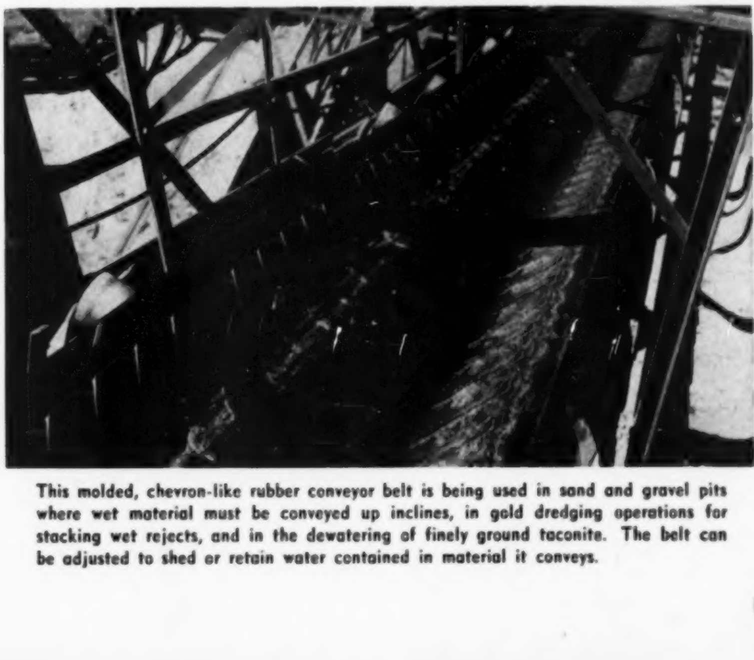
Humphreys to Operate Du Pont Ilmenite Plant

E. I. du Pont de Nemours & Co. plans to spend some $3 million on a mine and plant for the recovery of ilmenite, raw material of titanium metal and titanium pigments, near Lawtey, in north central Florida. The development will be somewhat similar to Du Pont's Trail Ridge ilmenite plant near Starke, Fla., which was described in the August 1953 issue of MINING ENGINEERING. Construction is scheduled to start within a few weeks, according to Du Pont. Operation is slated for early 1955.

Humphreys Gold Corp., of Denver, Colo., will build and operate the plant for Du Pont. They will also supply some of the equipment. Du Pont states that Humphreys Spirals are the key to the operation. Only about 2 tons of ilmenite will be recovered per 100 tons of sand treated.

First step in construction will be the laying of a railroad spur to the site. A *dry* mill will be built on land adjacent to the track. The dredge and ore separators will be floated in a channel scooped out of sand near the mill. In operation, they will pick up sand in front, take out the black ore, and pour the remaining sand back in again behind them. The water area will become a lake about ½ mile long and 500 ft wide.

From the *wet* mill, concentrates will be pumped ashore to the dry mill where it will be treated by electromagnetic and electrostatic separators. Waste treatment facilities are to be built into the plant, preventing water pollution. The entire operation, to be known as the Highland plant, is expected to have 100,000 tons per year output.



This molded, chevron-like rubber conveyor belt is being used in sand and gravel pits where wet material must be conveyed up inclines, in gold dredging operations for stacking wet rejects, and in the dewatering of finely ground taconite. The belt can be adjusted to shed or retain water contained in material it conveys.

Complete Electrification At Grassy Island Shaft

Hudson Coal Co. completed electrification of its Grassy Island shaft, permitting consolidation of all steam facilities for power generation in one building.

Undertaken as part of Hudson's modernization program, the project will free a considerable tonnage of steam-sized anthracite, now in short supply. Efficiency and safety will also be increased, according to H. H. Shaver, general sales agent of Hudson.

A total of 1200 hp has been installed for operation of the shafts, ventilating fans, and compressors. In addition, waste rock will be hauled to the Eddy Creek mine for disposal, eliminating need for another motor at Grassy Island, and making a saving in manpower.

Minimum Uranium Price Aid Extended to 1962

U. S. Atomic Energy Commission extended expiration date of the guaranteed minimum price schedule for uranium ores from the Colorado Plateau area. Time limit during which initial uranium ore from new domestic mines will be eligible for bonus payments was also extended.

The AEC Domestic Uranium Program Circular 5, Revised, was extended to March 31, 1962, from its previous expiration date, March 31, 1958. The circular originally became effective March 1, 1951. It provides guaranteed minimum base prices for the uranium oxide content of carnotite and roscoelite ores of the Colorado Plateau area. Price schedule ranges from $1.50 to $3.50 per lb of uranium oxide content, depending on ore grade, and certain allowances and premiums.

Domestic Uranium Program Circular 6, has been extended through February 28, 1957. The circular established a bonus for initial and certain other production of uranium ore from mines delivered under its terms between March 1, 1951 and February 28, 1954.

Leadridge on the Pabineau — Birth of a Mining Camp

Mr. Average Citizen, reading his newspaper between gulps of his morning coffee sees that Leadridge Mining Co., St. Joseph Lead Co. subsidiary, has just completed financial arrangements for a tremendously rich lead-zinc-silver orebody in New Brunswick. Chances are that's all that will register. He kisses his wife goodbye and between home and office devotes himself to the sports section.

What Mr. Average Citizen may never find out is that behind the cold lines of type is a story of 40 men who dug deep into the earth for more than a year, searching out the secrets of the orebodies, finding out if they were mineable, how much ore and metal they contained, and how much it would cost to reclaim the ore from the ground. Few if any of the literally thousands of words that have been written about the strike some 20 miles southwest of Bathhurst, N. B., have been about these men. Compared to the financial doings centered around the development, their activities may have seemed prosaic.

But walk into the camp after driving down the revamped log road, and quite suddenly the "big news" takes a back seat. A sign tells you this is "Leadridge on the Pabineau, Please Drive Carefully, We Love our Children."

The Pabineau is a creek that supplies the men with bathing facilities, and there are no women or children, or movies, or television, or luxuries. Any kicks that the men may get are contrived by the residents. Thus, everything gets into the act, even the tents where the crews live. They carry names reflecting the particular brand of humor prevalent in exploration camps. The four main streets, St. Joseph Blvd., Pleasant Ave., Theriault Turnpike, and Pabineau Ave., channel diamond drill crews and survey parties in and out of town.

Skyscrapers—Leadridge on the Pabineau style—crowd the four main thoroughfares of the town. Tents house drill crews and survey parties. A more permanent structure for a 14-man winter crew is under construction in the background.

The *town's* first real building is under construction on the south side, a 20x20-ft two-story affair to house the 14-man winter crew. Bathroom and reading room are on the first floor and the bunkroom is on the second. The 25 kv diesel generator and water pump will be in the basement. In spite of the building's modest dimensions, everyone feels that this is the concrete beginning of a great mining enterprise.

Ralph G. Alexander, in charge for Leadridge, is a teller of stories—and a good one. To him the camp is a great story—perhaps one of the greatest in his life.

"It's hard to say why, but everyone who works in this camp is dedicated to the job. Right now, we've got a mixture of men that ranges from old-timers to college kids. They all have one aim—the job. Everyone of them pitched in to make the signs, lay out the streets, and do other things that make life livable—youngsters and tough old-timers working together.

"It's rough here. A man gets one day off and one bath a week, and he takes his bath in a cold creek. It's hard to pinpoint reasons for the sense of belonging and the teamwork that exists, but exist they do to an almost unbelievable degree."

That's one of the things that the casual visitor senses immediately. Every man, no matter what his job is, lives in a state of almost constant excitement over what he is doing. It holds true if he works in the cookhouse, meat locker, core shack, or office.

Last September 7 the holdings of three large companies prospecting the area were merged. The companies were Brunswick Mining & Smelting Co., Anacon Lead Mines, and Leadridge. The joint company will take the name of Brunswick Mining & Smelting. Financial arrangements will provide \$25 million to bring the orebodies into production. St. Joe, through Leadridge, will furnish the initial \$7.5 million. An additional \$17.5 million will be advanced sometime in the future. Probably the most stunning fact is that one year after discovery, two major ore deposits have been proved and the company to operate and exploit the find has been set up.

The merger agreement provides that Brunswick Mining & Smelting, which originally issued a total of 1,931,000 shares of the five million authorized, will pay out 2,069,000 shares to effect the consolidation. Of this amount Leadridge Mining (St. Joseph Lead) will take 1,161,430 and the Anacon Lead Mines will have 772,430. The Brunswick group will retain control with M. J. Boylen as president, and St. Joseph Lead personnel will manage the operations. Frank Redfield, formerly with St. Joseph Lead at Fredericktown, Mo., will be in charge. Frank Cameron and George Brigden, St. Joe vice presidents, will be on the new board of directors.

—C. M. C. and M. A. M

Two old-timers of the Bathhurst area are Ralph G. Alexander of Leadridge Mining Co., and Walter H. Smith, on the right, superintendent of the Keymet property, already in operation.

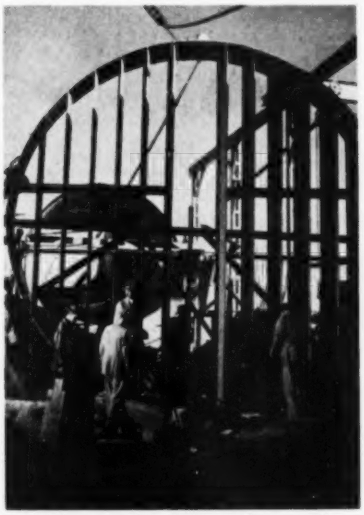
The Keymet headframe is under construction. Keymet, not on the same orebody as Leadridge, is the first operation to result from exploration in the area. Black structure is a cribbed bin.

Broken Hill Installing World's Largest Axial Flow Fan

To Serve Two Adjacent Australian Properties

The largest fan of its kind anywhere in the world is being installed at Broken Hill, New South Wales, Australia. The fan will provide ventilation for mines of the Zinc Corp. and New Broken Hill Consolidated, affiliated companies developing the silver, lead, and zinc field 700 miles west of Sydney. Both mines are operating at about 3000 ft. For reasons of economy it was decided to build the upcast airway on the common boundary of the two leases. The airshaft being used was formerly employed by the Zinc Corp. as a service shaft for development.

The Evase is the heart of the fan construction program. It is externally reinforced with ribs of precast concrete allowing walls to be fairly thin. Behind the evase is the concrete mixing plant which supplies materials for New Broken Hill's construction program.



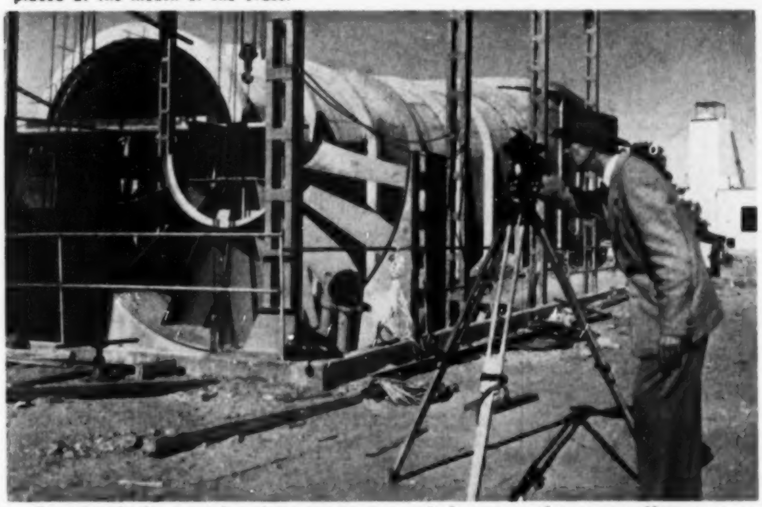
Workers install a giant guide vane that will deflect air drawn from underground into the blades of the axial fan to be placed at the mouth of the evase.

The fan, which will draw air into the mines from various downcast airways, weighs 42 tons with its carriage. It is said to be the world's largest axial flow fan, although not the most powerful. It was made by Walker-Macard, and is a 12-bladed single stage unit with a diam of 17 ft 5 in. and is directly driven by an 850-hp Mather & Platt induction motor.

The air stream is designed to leave the fan at speeds up to 43 mph. However, to ensure that air is continuously drawn up, a long, horizontal evasé has been built to expand and slow down the air to about 10 mph beyond the fan. The evasé is constructed of reinforced concrete and from the inside appears to be the hull of a half-completed ship. It has a diam of 17 ft 6 in. behind the fan and widens to a maximum of 28 ft. The evasé is circular in shape and about 32 ft long. It is externally reinforced with ribs of precast concrete thus allowing walls to be no more than 5 in. thick.

The axial flow fan is to be connected with the shaft by a concrete drift 20 ft in diam. A number of aerofoil section turning vanes will turn the upcast air from a vertical to a horizontal direction with little loss of pressure.

Behind the evase in the foreground, rises the new haulage shaft of New Broken Hill Consolidated. The mine aims at production of 1 million tons of ore annually.



Constant checks on work as it progresses are made by a crew of surveyors. Here, correct alignment is checked on the installation of a 7-ton axial flow vane at the mouth of the evase. Total weight of the fan, with carriage, will be about 42 tons.

The upcast airway is scheduled for operation by the end of this year. Zinc Corp. and Broken Hill have an objective of 1 million tons of ore annually. The ten-year program for developing and equipping the Broken Hill mine began in 1945.

Concrete Mixed Underground is Delivered by Air

International Nickel Co. is using compressed air to send concrete through pipes and into construction forms from underground mixing stations at its Creighton mine at Sudbury, Ont. Concrete mixing stations are located on the 6th and 20th levels. A raise formerly used for bringing rock fill into various levels of the mine is utilized to feed gravel from the surface to the mixing stations. Control chutes installed in the raise handle the gravel at each station. Cement is carried down on the mine's regular transportation system.

This is one of the underground concrete mixing stations at International Nickel's Creighton mine at Sudbury, Ont. The operator is pouring a bath of concrete from mixer into the long cylindrical placer from which concrete is blown by compressed air through pipe.

The mixers can produce a 16-cu ft batch of concrete every 3 min. Concrete is poured into the placer, a 2½x10 ft cylinder, and compressed air from the main air line is introduced. "Air borne" concrete is blown through a 6-in. steel pipe which deposits it, after a quarter of a mile of wandering through the mine, in forms at the construction site.

At 90° turns in the line T-bends are used. An air cushion which forms in the dead end of the "T" greatly reduces abrasion from concrete. On long curves sections of 8-in. pipe are inserted, with Ni-Hard liners which have an operating life under the impact of the concrete much greater than standard steel elbows.

Best *up* delivery thus far was a total of 1315 ft from the 20th level placer, consisting of 875 ft on 20th level, up 210 ft on a 47° incline, 100 ft on the level, up 50 ft at 90°, and finally 80 ft on the level. The longest *down* delivery came from the 6th level placer. Concrete traveled a total of 1670 ft from the placer into forms for a new slusher station on the 14th level.

Knapp to Participate In Mexican Lead Firm

An agreement has been reached between a U. S. firm and a Mexican group which may eventually bring Mexico into a strong position in the lead fabrication field.

Knapp Mills Inc., producer of lead clad steel and lead clad copper, has formed Knapp Mills of Mexico in joint ownership with Dominicis S. A. and Guillermo Barroso, Sr.

Mexico currently produces about 15 pct of the world's lead, but because of lack of skilled labor in lead fabrication must export its lead and then receive it back into the country in the form of finished products.

Mexico represents a growing market for finished lead products, according to a spokesman for Knapp Mills. The U. S. firm will teach Valezzi Sucs. S. A., for whom Mr. Barroso entered into the agreement, skills and methods needed for production of high quality lead products in exchange for exclusive distribution and sales rights of the products in Mexico and the U. S.

Only Mill Operates At Old Morning Mine

The mill on the Morning mine property in the Coeur d'Alene area will continue to operate despite the closing of the district's oldest continuous lead-zinc producer.

The Morning mine at Mullan, Idaho, was closed recently by American Smelting & Refining Co. because of increased cost of labor and supplies, diminishing ore reserves, and low metal prices, the company said. It had been a producer for 70 years. The mill will continue on a one-shift basis, handling ore from the Frisco mine in the same area.

Production at the Morning mine started in 1884 and in 1905 it was taken over by Federal Mining & Smelting Co. from its original owners, Larson and Greenough. AS&R acquired the mine when it merged Federal Mining earlier this year.

Morning mine is the deepest mine in the area—its lowest workings are 5200 ft below the surface. Peak year in the past 20 years was 1939 when about 24,000 tons of lead, 20,000 tons of zinc, and approximately 1 million ounces of silver were taken out. Production in 1952 was 4654 tons of lead, 6569 tons of zinc, and 163,110 ounces of silver.

Huge Iron Orebody Disclosed in Quebec

Discovery of an iron orebody of between 50 and 60 million tons about 80 miles north of Havre St. Pierre, 400 miles east of Quebec City, was announced by Premier Duplessis of Quebec.

According to a dispatch, no lease has been let on the orebody.

Reynolds to Exploit Haitian Aluminum Find

Reynolds Metals Co. is starting to develop its aluminum ore reserves in Haiti, according to Richard S. Reynolds, Jr., president of the firm. Development will proceed through Reynolds wholly-owned subsidiary, Reynolds Mining Corp.

Principal deposits of the company are about 80 miles from Port-au-Prince and near the port of Miragoane. Walter L. Rice, president of Reynolds Mining Corp., states that the deposits are about 5 miles from deep water, extending along a plateau 2500 to 3000 ft above sea level. A natural harbor assures loading facilities for the largest self-unloading ore carriers.

Drying and loading facilities will be on the shore and a pier to handle all types of carriers is to be constructed. Construction equipment has already been sent to ready the port area and to build a 12-mile road.

Reynolds and the Haitian government entered into a 60-year agreement in 1944. Deposits disclosed by Reynolds geologists are similar to those discovered in the Dominican Republic in 1944 and to those opened by Reynolds in Jamaica last year. The Jamaica project is operating at a 750,000 ton per year capacity. Something under that figure is initially planned for the Haitian deposits.

Japan Gets Iron Ore Blending System

First iron ore blending and reclaiming system ever built for the Far East steel industry has been shipped by Hewitt-Robins to Japan where it will become part of the new plant of the Kawasaki Steel Corp. at Chiba City.

The system has been in use in the U. S., Great Britain, South Africa, and South America. It makes it possible to blend ore of different physical and chemical characteristics at a rate of about 300 tons per hr, eliminating variations in ore grade.

Equipment shipped to Japan includes a reversible reclaimer, traveling boom stacker with trailing trippers, transfer car, hopper cars, samplers, and weightometers. Richard Kelly, Hewitt-Robins engineer, will supervise installation in Japan.

Two Orebodies Tested At Granduc Properties

Two possible orebodies and extensions were indicated by diamond drilling at the Granduc properties of Granby Consolidated Mining, Smelting & Power Co. Ltd.

Work on the properties this season consisted of 830 ft of tunnel and 4485 ft of diamond drilling, according to Julian B. Beaty, president, and Lawrence T. Postle, vice president. The property is located on the British Columbia coast.

Diamond drilling and tunneling of the first orebody indicated a length of at least 900 ft and an average width of 27 ft, with a copper content of about 2 pct.

Another orebody was located on the surface about 500 ft east of the first one. Diamond drilling indicates a length of approximately 400 ft, with both grade and width somewhat better than the first discovery.

The bituminous coal industry has recently completed this laboratory. It will house Bituminous Coal Research staff at Columbus, Ohio. Scope of the staff will include research, engineering development, and technical promotion.

ESPECIALLY significant in recent months in regard to alphabet agencies is the growing attitude of Republican administrators that what business needs is less regulation, and a closer adherence to the intent of Congress seems to be in order. What it all will mean to the mining industry is yet to be determined, but certainly a trend toward more freedom of action can only be of benefit to all concerned.

Ralph Demmler, new Republican chairman and head of the SEC, believes that a great deal of duplication has been going on. He feels that the SEC should surrender some of the regulating of public utility financing to state agencies. Mr. Demmler is also of the opinion that a great deal more detailed direction has been given than is necessary. Observers look for a less red-tape entangled relationship with the SEC in the future.

On another front the FCC is moving toward dislodgment of the log jam of TV station applications. They expect to be out of the woods in about one year. However, the American Bar Assn. warned that too much speed may result in unfair treatment in some cases. The FCC also plans to ease up on some of its investigations into radio station license sales and also may trim the number of questions on applications for license transfers.

One of the most important moves seems to be in the direction of a changed attitude toward freight absorption by manufacturers. Steel companies, for example, have been holding back in this direction since the 1948 Supreme Court decision on basing points. While the Truman administration voted approval of freight absorption, most industrialists felt that it was not a well-intended sentiment.

Another indication in the growing trend is that the FTC is expected to interpret antitrust laws differently. There will be fewer fringe case indictments, and the accent will be placed on gaining cooperation.

The picture as it stands now appears to offer evidence of a more judicious attitude, with a good deal of the crusading zeal of past years in the discard. However, when a cease and desist order is issued, it had better be obeyed or it can be expected that the agency concerned will get tough.

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ONE of the most unusual aspects of New York City provincialism is the unawareness of Mr. Average Citizen that a mining industry is going full blast just outside of his door. Actually, present and past mining history around the metropolitan area makes for a more than passingly interesting story. Recently, the *American Metal Market*, in an editorial, noted the 200th anniversary of the first steam engine employed in a mine in this country. The mine was the property of Col. John Schuyler and was located near North Arlington on the Passaic River. Its output of copper and silver was of such high quality that the British forced the owner to send the entire output to England.

Schuyler, after a visit to England, arranged to have a steam engine smuggled into the colonies. British miners were using the machine to operate mine pumps with great success. Josiah Hornblower, an adventurous Englishman, carried out the plan by having the engine broken down into component parts and packed inconspicuously in the hold of a ship. He eventually put the steam engine together again and it operated well for 20 years. Hornblower stayed on to become manager of the mine and later leased the mine in partnership with John Stearndall.

Hornblower wrote at least part of the opening chapter in American mining history. Eventually, he became an important figure in the new republic's political and judicial life, serving as a judge in Essex County Court of Common Pleas from 1790 until his death in 1809. In a true sense he pioneered an industry. If he had been caught attempting to smuggle the steam engine out of England, Hornblower would have been severely punished under laws aimed at keeping the colonies in the position of raw material suppliers to the mother country.

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ONE of the newsfront phenomena since the beginning of World War II and into the post war years, has been the world of materials allocations and controls. Its bureaucratic machinations, edicts, and rulings have been a major if paradoxical force in democracy. When a material is placed under control—or released from control—it becomes of vital interest to almost everyone. Definitely, the trend appears to be toward decontrol. Last month Washington announced that nickel restrictions were going by the board; the International Materials Conference disbanded its committee on cobalt, nickel, and manganese. However, the UN Conference on tin planned a meeting for mid-November which will attempt to halt the wild fluctuations in the price of tin.

While U. S. decontrol is not expected to immediately enhance the position of nickel starved civilian users, it will permit the forces of "competition in a free market" to operate as a major factor. Military and atomic energy needs have been assured. While nickel supplies will not meet demand for several months at least, decontrol offers promise for the future.

The International Materials Conference offered no nickel allocation suggestions for the fourth quarter. It felt they were not needed and in disbanding the committee it gave further proof of expected easier markets for nickel users.

As for tin, the same goal of price regulation was missed badly in 1950 when delegates to the conference failed to agree on a maximum and minimum world price. This time delegates will have a choice of several methods of price fixing—with a buffer stockpile plan as the major proposal. However, many experts feel that the buffer plan will meet with considerable opposition and the matter of price fixing will also come a cropper.

The U. S. has agreed to attend the conference—but with reservations. She does not wish it to appear that her attendance at the meetings will in any way indicate her willingness to go along with any plan which may develop.

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COLORADO FUEL & IRON CORP. has opened the first seamless tube mill west of the Mississippi at a cost of some $30 million. CF&I is aiming at markets in western U. S. and Canada. Seamless tube produced at Pueblo, Colo., will be readily available to oil and gas producers in Oklahoma, Kansas, Wyoming, west Texas, the Pacific Coast and western Canada.

One of the most spectacular installations of the mill is the giant 70-ft rotary furnace, one of the largest ever constructed for American industry. It can handle steel billets up to 2600 lb. The billets revolve slowly past flaming gas jets and are automatically discharged when heated to the required temperature. The furnace can handle 75 tons an hr, bringing the billets from room temperature to 2300°F.

Another outstanding achievement was the slicing into sections of a 100,000 lb-per-hr steam plant for shipment from Coffeyville, Kans., to Pueblo. The moving job was finished in 17 weeks. The entire CF&I steam generating plant was rebuilt without a shutdown.

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AMIDST the usual torrent of Soviet propaganda, Washington experts on Russian economics discern a note of genuine progress in the nonferrous metals field. The USSR, somewhat pinched by a nonferrous metals shortage, has completed the Ust-Kamenogorsk hydroelectric development on the River Irtysh in eastern Kazakhastan. The station is one of five projected by the 1950 five year plan. *Izvestia*, official Communist Party newspaper, claims that the new plant will increase electric power production in the eastern Kazakhastan area by some two and a half times, which in turn will increase mining and metallurgical activity. The Soviet newspaper stated that smelter output would step up by four times and additional mining and smelting facilities are to be installed.

The five year plan calls for a total installed capacity of 4,016,000 kw. Another plant is reportedly under construction on the Irtysh River above Ust-Kamenogorsk. The two plants will serve a region wealthy in zinc, lead, silver, copper, and gold. But more important is the adjacent Chinese province, Sinkiang, an area also rich in nonferrous metals. Russia and China are joint operators of two companies in the province, one for nonferrous development and the other for petroleum. Most experts consider the companies a pretty, legal fiction, with Russia actually running the show.

WITH all the pride of parenthood, Aluminum Co. of America unveiled its literally shiny new building on Pittsburgh's Golden Triangle. In an era in which architects are constantly experimenting with new materials to disclose never realized possibilities of beauty and function, the Alcoa building is unique. It is completely sheathed in aluminum, standing as Alcoa's proof of the maturity of the metal in the building trades. Inside and out, aluminum plays the major construction role. It is used for reversible windows, lighting fixtures, plumbing, air conditioning, ceilings, and other installations.

As Alcoa proudly notes, this super-application of aluminum to building construction is the result of many years of experiments. The Alcoa building itself went through many months of planning, model making, and engineering. Yet, when the long view is adopted, aluminum appears to be one of the infant metals. It was used in the 1880's for the cap atop the Washington Monument. However, aluminum was considered such a rarity that Tiffany's, Fifth Ave., New York jewelers, displayed the cap in its windows.

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DESPITE the contract signed by the U. S. for purchase of 10,000 tons of Bolivian tin concentrates it appears unlikely that former owners of nationalized mines will benefit. Under an agreement signed a short time ago the Bolivian Government is to pay for the mines on a sliding percentage basis figured on the market price for tin. The catch in the agreement is that it is operative in a price range of 80¢ to $1.21½ per lb. The current price of tin is below 80¢.

Eduardo Fajardo, secretary of Patino Mines & Enterprises Consolidated Inc., in a letter to company shareholders said: "In view of the steady decline in tin prices since the spring of 1953 to a low point of 71¢ per lb, it would be unrealistic to anticipate in the near future any substantial receipts under the agreement."

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FOR some unfathomable reason, newspapers and magazines in recent weeks have been filled with *think pieces* on the automatic factory of the future. The authors envision plants where raw material is poured in at one end and a finished product, after a series of operations untouched by human hands, emerges in pristine glory. But according to many engineers, the lack of human hands appears to be the flaw in the dream. They point out that for several reasons the automatic plant is an ideal—to be striven for but never attained in a complete sense.

Instruments must be tailored to human capabilities, said one engineer. Actually, the use of automatic control and production devices can be used to reduce the manpower needed and to minimize the chance of error—but they can never shunt human brains and skill into absolute obsolescence.


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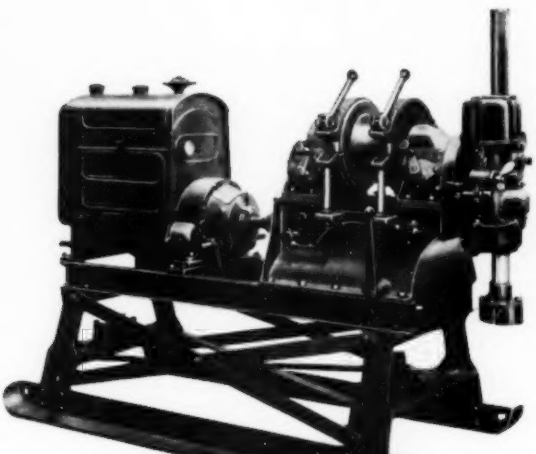

Whether you're mineral prospecting or looking for extensions of existing deposits, you'll wind up with the right information easier and faster by using the skid mounted CP-8 and CP-15 Diamond Core Drills. Specifically engineered to withstand the continued high drilling speeds made possible by bortz bits, they're available with gas, diesel or electric drive for surface drilling and air drive for sampling underground. And they can be readily moved from hole to hole under their own power. Bolted frame permits easy disassembly for transportation to remote sites. With E-EX fittings the CP-8 has capacities to 1250 ft., the CP-15 to 2250 ft. For more complete information, write: *Chicago Pneumatic Tool Company, 8 East 44th Street, New York 17, N. Y.*

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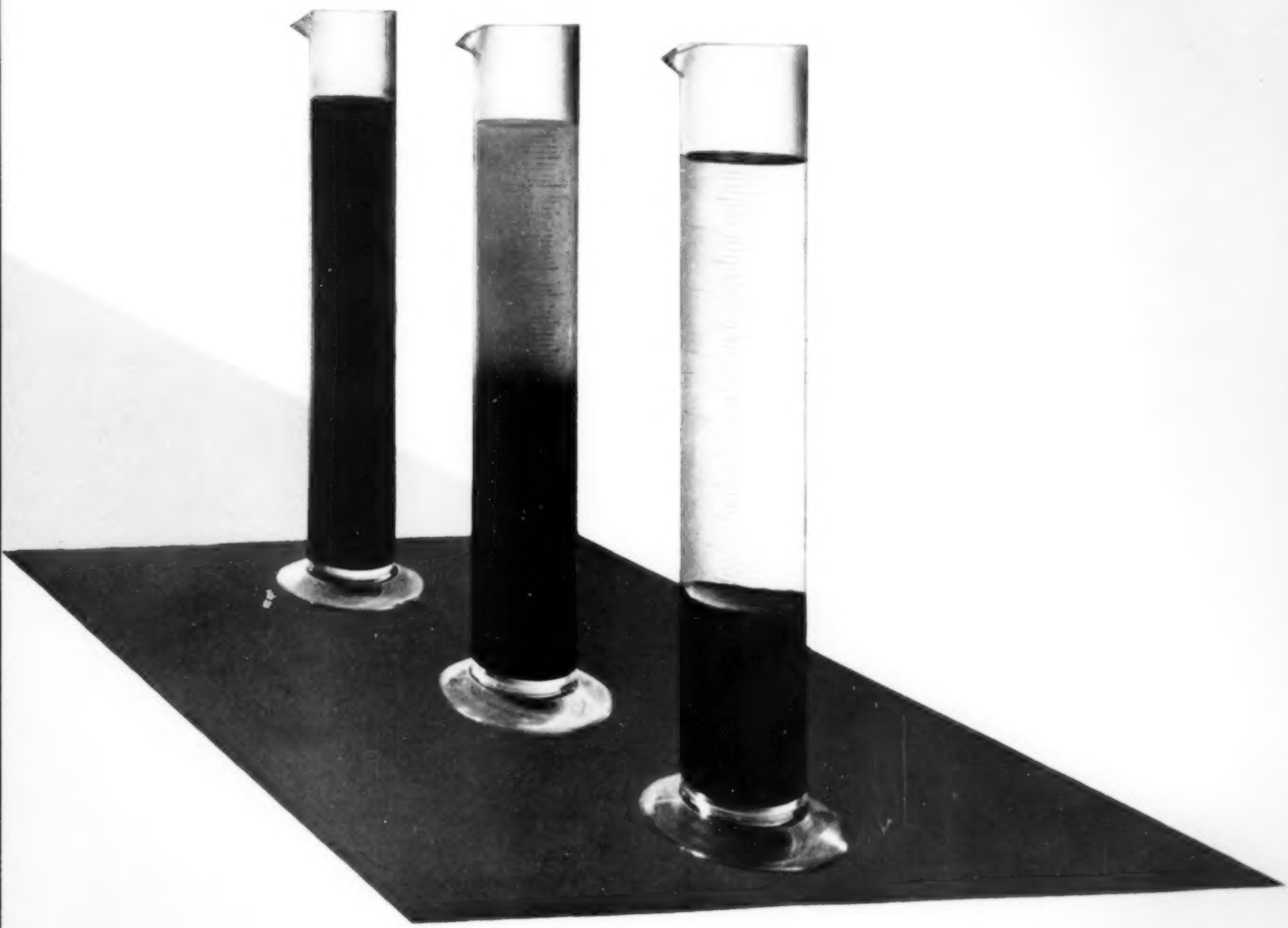
FOR FILTRATION—AEROFLOC* REAGENTS can

1. Increase filtration rates, make filter cakes firmer and more porous, help to prevent blinding of filter cloth and increase washing ease and efficiency.
2. Reduce capital expenditure by increasing capacity of filters.
3. Produce tailings for backfill that have a higher percolation rate, with the result that they settle faster and more firmly.

Often when filtering pulps thickened with AEROFLOC* Reagents these advantages accrue without further addition of AEROFLOC.



Several grades and types of AEROFLOC Reagents are currently available. Cyanamid Field Engineers are familiar with commercial results obtained with these reagents on a variety of ores in many mining fields. They will be happy to work with you on possible uses in your mill, to provide samples for mill-laboratory tests, and to arrange for delivery of quantities sufficient for your mill tests.

A letter or telephone call to the nearest Cyanamid Field Engineer or Cyanamid Office will get prompt and intelligent attention.

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Drift of Things

THOUGH a tentative offer from a group of industrialists in Pittsburgh is being seriously considered, and several meetings have been held, no decision had been made at the time of going to press on what is to be done about a new building for the national engineering societies.

The Pittsburgh offer results from plans to include an engineering center in the development now in progress in a triangular area at the confluence of the Allegheny and Monongahela Rivers. Land would be offered for sale to the engineering societies, and a substantial amount of money would be given for erection of a building—at least a million dollars and possibly considerably more might be forthcoming. Several other offers have been made by organizations in other parts of the country to provide land free of charge on which a building might be erected.

Opinion on whether or not the societies should leave New York is divided. The boards of the various societies are being asked to consider the matter promptly, as a decision is required well before the end of the year. —E. H. R.

IN this issue MINING ENGINEERING presents articles on the raw materials operations of Colorado Fuel & Iron Corp., a company whose mining *products* should be familiar to ME readers. As the introduction points out, CF&I's growth has been "expansion through diversification," but this neglects the most interesting human aspect of its growth.

CF&I has reversed the trend, has gone counter to the oft quoted and oft misquoted maxim of Horace Greeley. They went east.

Western operations have not been neglected. At Pueblo the West's first seamless tube mill will be turning out oil country goods, Allen mine is stepping up coal output, and other developments are taking place. Considering all its growth, however, the human interest still lies in the picture of this corporation coming from the west to carve out its place in the eastern industrial complex, as it rises to ninth place in the ranks of the steel companies. —R. A. B.

WE noted in the October 2 issue of the *Mining Journal* published in London, a considerable discussion of President Andrew Fletcher's speech to the Joint Meeting of the Canadian Institutes and the AIME. It specifically referred to his remarks on the various predictions regarding our waning mineral resources which have been made in the past 30 years.

They listed specific items and then asked the question "How does it come about that these [predictions] have been falsified by events?" Now quoting their answer to this question, "The answer is the adaptability of the human mind in devising methods by which mineral previously uneconomic, can be converted into ore—i.e. mineral gotten at a profit."

They carried this still further by quoting from Mr. Fletcher's Nova Scotia speech wherein he stated, "There can be no shortage of any commodity in a market where supply and demand function, for the price of the article will provide automatically a mechanism by which any maladjustment is corrected."

The interesting thing about this pickup by the *Mining Journal* is the importance of this subject of declining mineral resources. Mr. Fletcher's speech, from which they quoted, was given before a joint meeting of AIME, the Canadian Institute of Mining and Metallurgy, and the Mining Society of Nova Scotia at Keltic Lodge, Ingonish Beach, Nova Scotia. Yet the speech given at this out-of-the-way place, 75 miles from paved roads, was within less than a month given international attention.

WE have all heard numerous tales of the old mining camps like Leadville, Cripple Creek, and Tonopah, but few of us have had the opportunity to see these boom mining camps in their beginning. Only recently we had the opportunity to visit Bathurst, New Brunswick, and we could actually see the excitement and fevered activity of a coming mining area. The local hotels were all crowded with a multitude of prospectors, geologists, mining engineers, and opportunists, each having some valuable secret holding at his fingertips, which he could be induced to part with for a sum.

In the lobby of one of the larger hotels of this pulp paper manufacturing town, one could see dealers passing around numerous copies of documents which were obviously engineering reports covering some claim that had been just staked out. But, all these concentrated efforts were the background to methodical experts in the field of geology and geophysics who were carrying out well-planned exploration programs for old-name mining companies. And these experienced companies have situated themselves with economically feasible orebodies and are making plans for large-scale operation in the near future. It was very satisfying to see that the vigor of the old-time mining men is a reality and not a fable as many claim it to be. You could still see the gleam in the eyes of the aspiring *claim staker* that used to be called gold fever.

IN spite of the laws of the U. S. Post Office Dept., we received this letter. Although it is a variation on an old theme, it has unlimited possibilities.

Dear Friend:

This chain letter started in Reno in the hope of bringing relief and happiness to tired husbands.

Unlike most chain letters, this does not cost any money. Simply send a copy of this letter to five of your friends who are equally tired. Then bundle your wife up and send her to the man whose name is at the top of the list and add your name to the bottom of it. When your name comes to the top of the list, you will receive 16,478 women and some of them will be dandies.

Have faith! DON'T BREAK THE CHAIN. One man broke the chain and got his own wife back.

P. S. At the time of writing, a friend of mine had received 356 women.

Charles M. Cooley

Colorado Fuel & Iron Corp.

Expansion Through Diversification . . .

. . . And Dynamic Leadership

THE Colorado Fuel & Iron Corp., now the ninth largest firm in steel-producing capacity in the United States, is today hardly recognizable as the same company that was, a little over 20 years ago, a small western fuel and steel company with one major plant at Pueblo, Colo.

Now a nation-wide network of 14 modern industrial plants, making steel and steel products for almost every facet of American industry — mining, manufacturing, farming, construction, lumbering, electrical, bridge-building, oil and gas drilling, mass transportation, to name a few — Colorado Fuel & Iron has grown, in slightly over two decades, into a major U.S. producer of quality steel and steel products.

Since 1945, when Allen and Company acquired the CF&I properties, the growth and change in complexion of this company has been even more phenomenal. Men are the cornerstone of any company, and behind this development of a great modern corporation is an able staff — men who, under the leadership of Charles Allen, Jr., chairman of the board, and A. F. Franz, president, have laid down the far-sighted policies and overall planning that has brought Colorado Fuel & Iron to the front ranks of steel.

History and Expansion

by A. M. Riddle

GROWING out of the nation's most colorful era of railroad building, and with the vision of early pioneers who foresaw a great future for the Western Empire, the Colorado Fuel & Iron Corp. set as its objectives—

> The establishment and building of colonies, towns, schools; industries such as coal mining, iron making and manufacturing works; canals and roads.

This was the beginning of CF&I— in the year 1872, and from this small western beginning has grown a company that has achieved national importance, ranking ninth in size in steel producing capacity, with over 22,000 employees and operating 14 plants in strategic locations throughout the United States.

The growth of the Colorado Fuel & Iron Corp., with a doubling of its ingot capacity in little more than a decade to become one of the important steel producers of the country, has been accomplished by a plan of operation described in the annual report for the fiscal year ended June 30, 1952, as follows:

> The keynote of CF&I's program of expansion and modernization has been diversification. This has been accomplished by finding new uses for present products; developing new products for the various industries the corporation serves, and by acquisition of companies that have added new products, new customers, and new markets.
>
> Diversification of products has been made possible by the diversification of manufacturing processes, including not only the addition of new machinery and equipment, but also changes and improvements in present equipment, plant layout, metallurgy, and other operating practices.
>
> Diversification has proved its worth, and will be continued, because it has helped to balance production, maintain high level output, control cost, improve customer service, and strengthen the corporation's competitive position in the industry.

The companies that are now under the banner of the Colorado Fuel & Iron Corp. have had long and interesting histories of growth and development, and CF&I's products are now shipped to every state in this country and to many foreign countries. They have had an important role in helping build the industrial strength of America. The new CF&I now has a solid foundation for even greater industrial achievement.

Prior to 1937, CF&I was a single plant operation with a steel plant located at Pueblo, Colo. Consolidations with other companies which have had an important bearing on its growth, started in 1937 with the acquisition of the California Wire Cloth Corp., with two plants in California. In October 1945, the Wickwire Spencer Steel Co. was acquired with plants in Palmer, Clinton, and Worcester, Mass., in Buffalo, N. Y., and including a subsidiary company, American Wire Fabrics, with a plant in Mt. Wolf, Pa. In March 1951, a steel plant at Claymont, Del., was acquired from the Worth Steel Co. In January 1952, the E. & G Brooke Iron Co., at Birdsboro, Pa., together with its mining subsidiary, Richard Ore Co., Wharton, N. J., was added to the group, and on Dec. 31, 1952, the plants of John A.

A. M. RIDDLE is manager of the CF&I market research and statistical dept. at Denver.

This is one of the earliest views of the Pueblo plant, an artist's sketch that appeared in an illustrated supplement of the *Pueblo Chieftain* in 1888. Behind the blast furnace are the Spanish Peaks, seen by Coronado's explorers in the Sixteenth century.

Roebling's & Sons Co. at Roebling and Trenton, N. J., were acquired.

In looking back to CF&I's early history, records show that the Colorado Coal & Iron Co. was first formed for the purpose of manufacturing iron, steel, and coke, and for the mining and selling of coal. This company was a consolidation of three companies previously formed, but which were limited in scope and in capitalization.

The first act of the Colorado Coal & Iron Co. was the erection of a blast furnace at Pueblo. This furnace—the Betsy—went into blast on Sept. 13, 1881. It was not a large producer, but it foreshadowed an era of industry development that has progressed steadily as the West has grown in the production of raw materials and the increasing utilization of these materials into finished products.

In 1892 the Colorado Fuel & Iron Co. came into corporate being by the merger of the company previously existing and the Colorado Fuel Co. The former name was changed in 1936 to the Colorado Fuel & Iron Corp.

The first rails were rolled at Pueblo on Apr. 12, 1882. The Pueblo plant is still the only producer of steel rails and fastenings west of the Mississippi. In 1930, rails and fastenings made up 70 pct of total tonnage shipped. Since then CF&I's portion of the industry's total shipments of rails and fastenings has increased, but today these products account for less than 20 pct of the corporation's total sales.

Coke for the steel plant first came from beehive oven plants located near the coal mining properties. Coke was first made in the new byproduct coke oven plant at Pueblo in July 1918, which also produced many chemical byproducts. Later the beehive ovens were abandoned.

For over 70 years the Colorado Fuel & Iron Corp. has been engaged in the making of pig iron, and hence its practice has been developed through all of the successive stages of advancement that have taken place in the country.

The first metal, other than pig iron, to be made at Pueblo was puddled iron from which cut nails were made. In later years the manufacture of this metal was discontinued, when a Bessemer converter was placed in service, and steel replaced iron. However, there were many new developments in the early years and the Bessemer process, especially for the manufacture of rails, was later superseded by the open hearth process. There are 16 furnaces in operation and in recent years they have been modernized and enlarged, and new production records established.

The manufacture of wire and wire products at Pueblo has been carried on since 1901, and the

The CF&I Story

"One of the ways a company can grow, perhaps the most interesting one, is by diversification . . . Such is the case of the Colorado Fuel & Iron Corp."

With this introduction JOURNAL OF METALS presented the complete story of CF&I—from raw materials, through fabrication, to sales—in its October issue. In order to place emphasis on developments of interest to its readers, MINING ENGINEERING is presenting the full story of the raw materials phase of CF&I operations.

The complete version in the October 1953 issue of JOURNAL OF METALS covered: Operations—Pueblo, Buffalo, Palmer, Morgan, Clinton, E & G Brooke, Claymont, and Pacific Coast; Subsidiaries— American Wire Fabrics Corp., and John A. Roebling's Sons Corp.; Plant Interrelationship; Transportation; Purchasing; Industrial Relations; and Merchandising.

yearly output of these products has been steadily increased. Many new products have been added in recent years, including coiled baling wire, strand, and specialty wires.

In 1937 the California Wire Cloth Corp. was acquired by CF&I. Calwico, the trade name for California Wire Cloth, operates a plant in Oakland and one in South San Francisco, Calif., and from rods shipped from Pueblo's modern rod mill, produces a wide variety of wire and wire products for the markets of the Pacific Coast and other western states. The history of Calwico dates back to 1859 and brought to CF&I a long history of wire drawing, wire weaving, and wire fabricating skills. Today Calwico, in addition to the products of its own plants, also distributes many other products manufactured at the Pueblo plant and at the various plants in CF&I's eastern div. Effective July 1, 1953 the business, operations and properties of the California Wire Cloth Corp. were transferred to the Colorado Fuel & Iron Corp., and are now operated as the Pacific Coast div. of the corporation.

The Wickwire Spencer Steel Co. traces its beginning to 1821, when a small workshop was set up to experiment in the drawing of fine wire. In 1920 the Wickwire Spencer Steel Co. was formed, which combined the Spencer Wire Co. and the Clinton Wright Wire Co.

The Agreement of Merger between the Colorado Fuel & Iron Corp. and Wickwire Spencer Steel Co., dated Aug. 2, 1945, combined the research, production, and distributing facilities of two important companies and established the pattern of CF&I's nationwide distribution. CF&I and its subsidiary, the California Wire Cloth Corp., joining with Wickwire Spencer and its subsidiary, American Wire Fabrics Corp., brought a new nation-wide service in steel, wire products and allied specialties.

In March 1951, CF&I acquired the Claymont, Del., steel plant from the Worth Steel Co. and this plant is now a part of the Wickwire Spencer div. The history of this company goes back over 100 years and its production of wide plates, plate specialties, and large diameter transmission pipe, gave the corporation its first line of wide flat rolled products.

In January 1952, the E. & G. Brooke Iron Co. at Birdsboro, Pa., and its subsidiary, Richard Ore Co., which operates an iron ore mine at Wharton, N. J., became a part of CF&I. It is now a part of the Wickwire Spencer div. Brooke was established in 1788 and its blast furnace plant provides not only an assured supply of pig iron for the expansion and modernization program in progress at the Claymont plant, but also additional tonnage for other pig iron consumers.

The latest addition to CF&I's group of plants on Dec. 31, 1952, was the John A. Roebling's Sons Co. Roebling operates plants in Trenton and Roebling, N. J. It was founded in 1876 and has established an enviable record for quality products. The Roebling Co. has been one of the pioneers in the field of wire specialties, wire rope and strand, electric wire and cable, strip, and bridge construction materials and services. One of its first notable achievements in engineering design and construction was the famous Brooklyn Bridge, completed in 1883.

As a result of the new concept of management and the full cooperation of its employees, CF&I is an entirely different corporation today than it was in 1945. This has been made possible by the solid belief in the enterprise and the aggressive policies of the board of directors, headed by Charles Allen, chairman, and also by the continuing confidence of financial institutions and other investors, large and small, located throughout the country.

CF&I has been fortunate in having good basic plants on which to build, and its progress has also been due in great measure to the enthusiastic and capable manner in which operating, sales, and administrative personnel with long experience in the steel business, have followed the leadership of Al Franz, president of the corporation, in building its present high and favorable position in the steel industry.

It was recognized that improvement and modernization was the first essential step in making the corporation strong, starting at the mining properties, carrying on to the steel producing and finishing operations, and then on through the various channels of distribution to meet the needs of the ultimate consumer. All steps have been taken only after complete engineering and economic analysis.

The job of building the *new* CF&I has been thorough, but the possibility of even greater growth and development lies ahead. In an address to the New York Society of Security Analysts on Jan. 8, 1953, President Franz made this statement:

> CF&I faces the future with confidence. We sincerely believe we have built well, but our job is not finished. Some of the improvements are newly completed, or are still in process. The work that has been done is still not fully effective or measurable in terms of economic realization. We will continue to use research and diversification as a basic theme for progress and when worthwhile changes are indicated we will make them.

In 1902, many of the mills of the Pueblo plant were new, the turn of the century having been one of the greatest periods of expansion for the plant. By December 1901, three blast furnaces were in operation, two new furnaces were being built, the Bessemer converter was to be enlarged, the rail mill was enlarged to 1200 tons a day capacity, and the open hearth and five new rolling mills were under construction.

CF&I Raw Materials

Western Operations

by G. H. Rupp, R. L. Hair,

and M. L. Sisson

THE iron ore supply for the Pueblo plant of CF&I is obtained from the Sunrise mine in Wyoming and the Duncan and Blowout mines near Cedar City, Iron County, Utah. The Sunrise mine is an underground operation while those in Utah are open pit.

Sunrise Iron Mine

Since 1941, the entire production of Sunrise mine has been from underground operations. Between 1941 and 1945, the entire production was mined by the block caving system. Since that time, an average of 25 pct of the production has been mined by sublevel caving methods.

The sublevel caving method is similar to that used on the Iron Ranges. The sublevels are on 25-ft vertical intervals with the mining drifts on 25-ft centers. Twenty-five hp, dc scraper haulers are used for mucking the ore in the mining drifts. Other 25 or 40 hp, dc, scraper haulers are used on the sublevel below the mining level to cross-haul the ore to main transfer raises, from which it is loaded into cars and transported to the main ore pockets.

Sublevel mining is used on portions of the orebody which cannot be mined economically by block caving due to irregular outline or insufficient height. General features of the block caving system used at Sunrise mine are described in *Block Caving at Sunrise Iron Mine, Wyoming*, by George H. Rupp, *Trans.* AIME, 1939.

The various third level blocks described in the paper have been mined out. The tonnage recovery averaged 108.1 pct. While the average analysis of the ore as mined was 3 pct lower in iron than the estimated analyses of ore in place, the metallic iron recovery was 102 pct due to the overdraw.

A few changes have been made in the block caving system to meet varying conditions. The haulage drift spacing was changed from 50-ft centers to 60-ft centers. This, in turn, increases the grizzly drift centers from 25 to 30 ft, and increases the draw area of each grizzly position from 375 to 450 sq ft. This increase in drift spacing has had no undesirable effects on the caving or recovery and had the advantage of permitting the use of 30-ft instead of 25-ft radius curves in the haulage drifts.

Since 1941, the main production has been hauled in 120-cu ft cars of the low head box type that are dumped by 19-in. air cylinders at the pockets.

G. H. RUPP is manager, mining department, Pueblo; **R. L. HAIR**, general superintendent, fuel mines, is also located at Pueblo. **M. L. SISSON** is superintendent, Sunrise mine, Sunrise, Wyo.

View shows headframe and picking plant at Sunrise mine, Sunrise, Wyo. Mine operates on a two shift basis, while the plant operates one shift. Headframe is 199 ft high.

The rapid depletion of reserves during the war years necessitated opening up a lower level. A new plant had to be put in, consisting of a new shaft, headframe, screening and picking plant, railroad yards, power and hoist house, hoists, compressor, underground haulage drifts, sumps, and pumping plants. This project was started early in 1943, and completed and put into operation in 1945.

The No. 3, or Wright, shaft is a six-compartment combination shaft measuring 14x22 ft 6 in. outside the steel sets. Two compartments are for skip-hoisting of ore, one for cage-hoisting of men and material, one for cage counterweight, one for air and water lines and power cables, and one for ladderway.

Two main shaft stations are located on the third and fifth levels, at 350 ft and 550 ft from collar of shaft. There is also a cage landing station at the bottom of the shaft. The third level station is connected to the old third level workings by 9x10 ft haulage drifts. On the fifth level, 9x10-ft drifts were driven in rock to the main orebody. From these drifts, haulage drifts in the ore were driven for block caving. The fifth level caving blocks are the major producing areas at the present, and have been in production since 1946.

A single skip-loading point is located 160 ft below the fifth level. The skip-measuring pockets and surge bin are of steel and concrete construction, and are served by three storage raises to the car dumping points on the fifth level.

Two transfer raises from the third level connect with two of the fifth level storage raises. This system of storage raises permits transfer of third level production to the skip-loading point. All of the raises are equipped with 48-in. arc type chute gates and operated by 14-in. diam air cylinders.

Ten feet below the fifth level, a sump of 1 million gal capacity was driven with a pump room. The pump room has four electric centrifugal pumps with a combined capacity of 2200 gpm.

The structural steel headframe screening and picking plant and loading bins are an integral unit. The headframe is 199 ft from foundation to high point; the cage and counterweight sheaves are 176 ft above the foundation. All the head sheaves are 10 ft diam, equipped with roller bearings.

The skips, 8-gross ton capacity, dump into a bin at the top of the screening and picking plant. At the bottom of this bin is a 60-in. heavy duty manganese steel pan feeder. This feeds the ore onto a 6x14-ft heavy duty, double deck vibrating screen which separates the ore into three sizes: +12 in. −5 in.; +5 in. −2 in.; and 2 in. The two large sizes pass over 48 in. belt picking tables where gangue and other refuse is removed by hand picking. The amount of picked rock varies between 6 and 7 pct of the finished product, or an average of about 18 tons of rock per picker per shift.

A 100-ton steel loading bin with an independent railroad track and scale is provided for each screened size. The screening and picking facilities can also be bypassed and straight mine run loaded through one of the bins. Mine waste rock also bypasses the screening plant and is transferred by chutes to a 100-ton rock bin. The picked rock is carried by a 36-in. conveyor belt to this bin, from which it is trammed in a 50-ton air dump car by electric locomotive and wasted in the old open pit.

The hoist house is a fireproof brick and steel structure 190x60 ft and houses the ore hoist, man and material hoist, three air compressors, two motor-generator sets, and accessory equipment.

The ore hoist is a double cylindrical drum 10 ft diam x 6-ft face, single gear reduction driven by 1250 hp, dc, motor with a 1000-kw Leonard type synchronous motor-generator set and amplidyne control. The man and material hoist is a double drum 10 ft diam x 6-ft face, powered by 250 hp, 2200-v, ac, motor with magnetic control.

Compressed air for drilling and operation of chute, skip and bin doors is furnished by any combination of three compressors. These are 2200, 3500, and 6000 cu ft capacity. The compressed air is passed through an aftercooler and transmitted through 12-in. pipe line to the bottom of the shaft. Each level is served by an 8-in. line.

It has been demonstrated that the control of dilution and also control of the caving action, as well as weight control, has been more difficult in the fifth level blocks than it was on the third level. This is due to the fact that the third level blocks were located under the solid limestone capping, while the fifth level is largely under the old open pit, which is partly filled with rock, which was caved off the walls of the pit. This rock, consisting of both schist and capping, has a much greater tendency to run and fill any open area in the cave than the capping did in other blocks. The greater depth increases the weight and makes the maintenance of grizzly drifts more difficult. In addition, we have had some weight on the haulage drifts which we experienced only to a very minor extent in the third level blocks. A total of 9,107,000 tons have been produced by block caving method since it was started in 1930.

A few small blocks of ore are being developed to mine by block caving, but the grizzly drift is a slusher drift, and the ore is pulled to the haulage drift by scrapers instead of dropping through main raises. This eliminates considerable development in haulage drifts and main raises, and permits the mining of orebodies of less height than by the conventional block caving method. The grizzly drift is driven either at the elevation of the top or bottom of the haulage drift.

This method has been used only to a limited extent, but it is proving more satisfactory on Sunrise ore than the sublevel caving.

Blowout and Duncan Iron Mines

These two current open pit operations are located in the Pinto iron mining district 20 miles west of Cedar City, Utah. Cedar City is 265 miles south of Salt Lake City on U.S. Highway 91. A branch line of the Union Pacific Railroad, from Lund, services these operations. Workers for Utah Construction Co., the present contractor engaged in mining these orebodies, commute from Cedar City.

Iron ore was first discovered in this district about 1850 by early Mormon settlers. In March of 1853, some pig iron was produced locally, but the venture failed. In 1866, an attempt was made again closer to the deposits to produce iron from the Duncan orebody with the result that pig iron in varying quantities was made for 25 years.

Around 1900, CF&I became interested in the district and acquired numerous claims, including the Blowout and Duncan orebodies, but it was not until 1942 that exploration work was started with a view to opening up these deposits.

The first ore was shipped from the Duncan orebody in 1943 to the Pueblo steel plant, and four years later shipments were started from the Blowout pit. Operations have been continuous ever since, with these mines supplying over half the ore requirements of the Minnequa plant.

The Blowout body, at present the main producer, is a combination contact and replacement deposit. This ore is a hard, massive magnetite, which is an ideal ore for open hearth operations. The Duncan orebody, entirely a replacement type deposit, is 60 to 70 pct magnetite and 30 to 40 pct hematite. The ore is soft, black, and granular. The higher sulphur content of a large amount of the remaining ore has curtailed mining of the Duncan pit, but the ore is currently being mixed with Blowout ore, the combination of which is very satisfactory for blast furnace operations.

At the present time, the mining activity is centered principally at the Blowout pit, this operation employing two power shovels and eight haulage trucks. The trucks dump the ore directly into a 5x14-ft pan feeder, which feeds it to a 48x60-in. jaw crusher. The − 6 in. crushed ore is then conveyed to a stockpile that has a 12,000 ton live storage capacity. There are separate stockpiles for Blowout and Duncan ores. Three x 8-ft pan feeders under the stockpiles discharge onto 36-in. wide conveyor belts which transport the ores to a small mixing bin. From the mixing bin, the ore is conveyed to a double deck vibrating screen located over the two loading bins in the tipple. Four products are shipped: 6x2 in. Blowout open hearth ore; 2x0-in. blast furnace ore; 6x¾ in. blast furnace ore (Blowout and Duncan mixed); and ¾x0-in. blast furnace fines (Blowout and Duncan mixed). The loading tipple has a capacity of 200 tons per hr and normally operates two shifts per day.

To insure future supply, another large open pit mine is being developed by the corporation in this area. This will require the construction of two miles of railroad, new plant facilities, and some changes in mining practice to conform to new conditions.

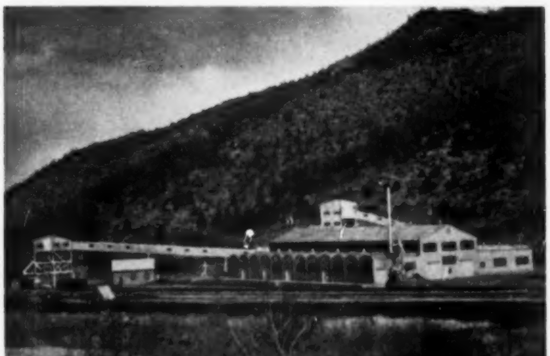
Allen Mine

Modern, mechanized coal mine ranks with largest in the West — plays major part in CF&I's broad expansion program

COLORADO FUEL & IRON CORP. operates five coal mines. Two, the Kebler and Pictou, are in the noncoking area in Huerfano County, Colo. These two mines produce coal for the domestic and commercial markets and for railroad engine fuel. They also ship a limited amount of slack coal to the byproduct coke ovens at CF&I's steel plant in Pueblo for blending with heavy-coking, high-volatile coals from Las Animas County, and with the low-volatile coal mined and shipped from Arkansas.

The three coking coal mines, Morley, Frederick and Allen, are located in Las Animas County, Colo. Morley and Frederick mines were opened in 1907, and have been in active operation ever since. They produce an excellent grade of coking coal.

In keeping with CF&I's general expansion program it was found necessary to open a new coal mine to provide a capacity of 6000 tons per day. This mine is among the largest in the western part of the country, and also ranks among the most modern mechanized mines in the U.S. The need for a new, high production coal mine became evident several years ago, and an extensive exploration program initiated at that time, entailed a large number of diamond drill holes, and the driving of 1000-ft prospect entry. The results of the prospecting, substantiated not only by laboratory tests but by actual coking practice in standard byproduct ovens with coal from the prospect entry, provided for the decision 2½ years ago to open the Allen mine, named for Charles A. Allen, Jr., chairman of the board of directors. Allen mine is located in the Stonewall Valley on State Highway No. 12, 30 miles west of Trinidad, county seat of Las Animas. Planning ahead for this new operation is evident in the fact that the installations are substantial and permanent, pointing to low maintenance cost of operations over a projected mine life of many years.



Primary industrial group building of Allen mine is located at the East Portal. Tipple, hoist house, and industrial and administrative building can be seen in this photograph.

Colorado's famed Sangre de Cristo range is in the distance in this view of the Allen mine portal. The mine car is an 8-ton drop-bottom type with automatic couplers.

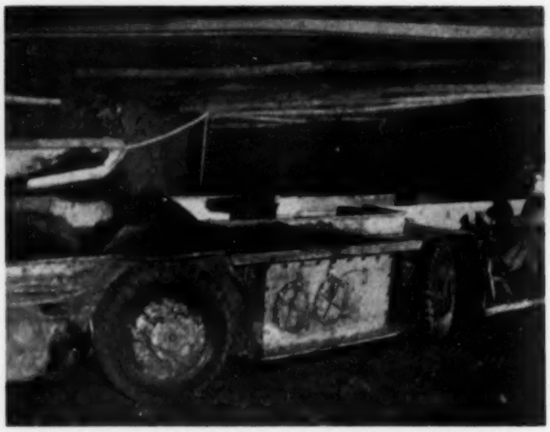
Railroad Service

The railroad serving the Allen mine is the Colorado & Wyoming Railway, a subsidiary of CF&I. To prepare to handle the capacity production from Allen mine, it was necessary to relay the track from Jansen to Weston, a distance of 16 miles, and to build an entirely new railroad for 10 miles from Weston to the mine. The roadbed for its entire distance is laid with 115-lb rail on creosoted crossties. Jansen is 4 miles west of Trinidad, and is the easterly terminal of the southern div. of the Colorado & Wyoming Railway, and also the interchange point with the C&S, the AT&SF, and the D&RGW. The Frederick mine, 9 miles from Jansen, is also served by the Colorado & Wyoming Railway. In other words, the three large railroads mentioned above place railroad cars on the interchange tracks at Jansen for loading at Frederick and Allen mines. The Colorado & Wyoming uses diesel-electric motive power for hauling the coal cars back and forth from Allen and Frederick mines to Jansen. The three independent railroads handle the coal the 94 miles from Jansen to the Minnequa steel plant in Pueblo. This assures the two mines on Colorado & Wyoming rails of a dependable supply of coal cars. The Morley mine is located about 12 miles south of Trinidad on the AT&SF.

Surface Plants

The construction of surface facilities will permit the handling of 6000 tons per day over the planned life of the mine.

West Portal: The industrial group building is 60x220 ft, of steel frame and corrugated sheet steel construction. It houses the stoker-fired heating plant, miners' shower and change rooms, foreman's office, lamp room, storehouse, and mechanical, blacksmith, and electrical shops. The mine supply track extends into the shops for convenience in setting in heavy



Shuttle car at the receiving end of a loading machine holds 4 tons, and can be loaded in half a minute. The roof is supported by channels and split rod and wedge type bolts.

This panel belt is discharging coal into one of the 8-ton drop-bottom mine cars. Belts may be fed by shuttle cars or shaking conveyors, depending upon the mining cycle.

equipment to undergo repairs. An unloading dock and supply railroad track is built along the north side of the industrial building for easy unloading of materials and supplies. A 12-ton diesel locomotive on 48-in. gage mine track handles mine supplies and materials on the surface between the warehouse, mechanical and electrical shops, storage yards, powder house, and the side tracks at the mine portal.

East Portal: The primary industrial group building consists of a center bay 50x246 ft, where heavy underground equipment will undergo repairs, with extensions on each side 40 ft and 50 ft wide. Overall size of building is 140x246 ft. An unloading dock and supply railroad track similar to that at the West Portal is also built along the north side of the East Portal industrial building. This building houses the stoker-fired heating plant, shower and change rooms, shops, etc., and at the east end there is a two-story brick section which houses the mine offices, superintendent's office, medical dispensary, engineer's office, laboratory, and an assembly room. All surface facilities at Allen mine are contained in the two group buildings at the East and West Portals, except, of course, the preparation and loading facilities, hoist houses, mine ventilating fans, garages, and power house. A 12-ton diesel locomotive at the East Portal transports supplies and materials on the surface. At both the East and West Portals concrete underpasses are provided for travel of workmen from the parking lots on the north side of the railroad tracks to the change rooms.

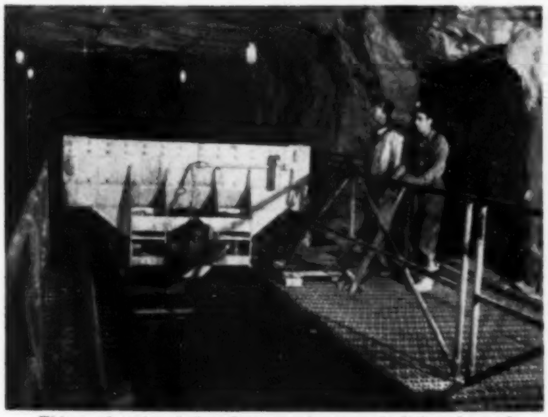
Tipple facilities are essentially similar in design except that the East Portal plant is laid out to handle a much larger production of coal than the West Portal plant. At the East Portal, coal and rock are brought out of the mine on a 48-in. belt conveyor, 8-ply nylon, terminal centers of 1577 ft, operating up a 30 pct pitch from underground bins. When rock is brought out on the belt, it is diverted into a 100-ton bin at the head end of the belt by means of a mechanically operated flop gate and is then hauled away by dump truck.

Coal from the 48-in. belt is discharged onto a 6x14-ft vibrating screen, where +3-in. coal is screened out when needed to keep the employees' domestic 25-ton coal bin full. The +1½ in. coal is diverted to a 9x22-ft rotary breaker and the −1½ in. bypasses the breaker and discharges onto the belt conveyor extending from the breaker to the loading chutes at the tipple. The refuse from the rotary breaker discharges to a 25-ton rock bin for dump truck disposal. The rotary breaker reduces the +1½ in. coal to −1½ in., and this, together with the bypassed −1½ in. coal, is transferred by the belt conveyor to chutes over three loading tracks. This belt is 48 in., 5-ply, 319-ft centers, and operates up a 9 pct pitch. In addition to breaking the coal, the rotary breaker rough cleans the coal when there is a pronounced difference in the hardness of the coal and rock.

Tipple design provides for loading coal on any of the three tracks by means of *pants* type chutes and push-button controls. Railroad cars are dropped to the loading chutes by means of two air-controlled car droppers, and an electric car puller is used in bad weather. All the equipment has electric interlocking controls and one operator at a console in the tipple handles all these units.

At the West Portal, the run-of-mine coal is dumped from the 8-ton drop-bottom cars into a 55-ton bin. The rock brought out of the mine in mine cars is dumped into a 100-ton bin and then elevated by pan conveyor to a truck-height chute, where it is hauled away by a dump truck. The mine run coal from the 55-ton bin is fed by reciprocating feeder to a 36-in., 5-ply, conveyor belt, 134-ft centers, on plus 29 pct grade which discharges it onto a stationary grizzly screen set on a 30° slope. The −1½ in. coal goes directly to the conveyor belt under the breaker, and the +1½ in. coal goes to the 9x17-ft rotary breaker for rough cleaning and sizing to −1½ in. The 1½ in. screened and broken coal is then conveyed on a 30-in., 4-ply, 252-ft centers, belt conveyor on a 6 pct downgrade to the tipple, where it can be loaded on either of two loading tracks by pants type loading chutes. A push-button control panel at the tipple control house has control of all the equipment beginning with the reciprocating feeder at the coal bin and ending at the loading chutes at the tipple. Railroad cars are handled by two compressed-air car droppers operated from control room. Preparation and dumping facilities at the West Portal are similar to those described above for the East Portal except that they are not so large in scale.

The coal seam has been well located throughout the property by core drilling and underground pros-



This coal train of drop-bottom mine cars is being dumped at the underground bins of the East Portal. This portal uses a 48-in. belt conveyor to move coal to the surface.

A view of the man and material slope of Allen mine's East Portal. The second slope at this portal houses the 48-in. conveyor. Note the use of both roof bolting and guniting.

pecting. The seam varies in thickness from 4 to 6 ft. The geology of the coal deposit indicates the seam to be on the western edge of a syncline, with the coal at the west end of the field having a dip of 25 pct to the east. As the seam continues eastward, the dip lessens in severity and within a distance of 2 miles it has a pitch of only 2 pct.

Mine Layout — Room And Pillar System

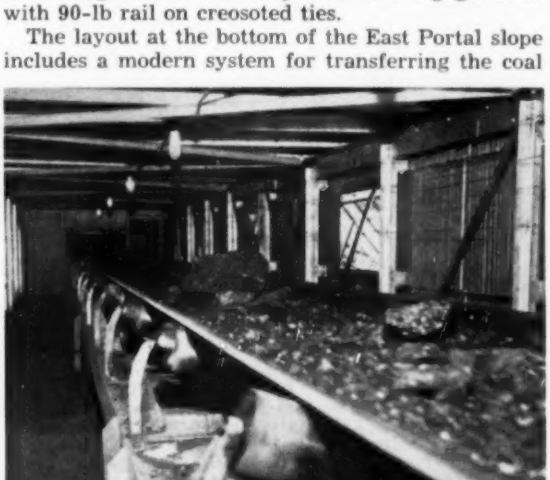
Allen mine is actually two mines in one. Coal is brought out of two openings and prepared and loaded over separate tipples. At the West Portal coal is hauled from the mine in 8-ton, drop-bottom cars by a 12,000-lb rope pull, single-drum hoist and 1¼ in. haulage rope.

The East Portal has been slower in development, due to the driving of a pair of rock slopes from the surface to the coal seam. The parallel tunnels on 80-ft centers were driven 1500 ft on a 30 pct dip. Each is 8 ft high, 12 ft wide, rock-bolted, and the walls and roof are gunited. One tunnel houses a 48-in. belt conveyor designed to handle 700 tons of mine run coal per hr, at a speed of 400 fpm. The other tunnel is used for handling men and materials by a 12,000-lb, single-drum rope pull hoist and 1¼ in. haulage cable. The slope has 48-in. gage track with 90-lb rail on creosoted ties.

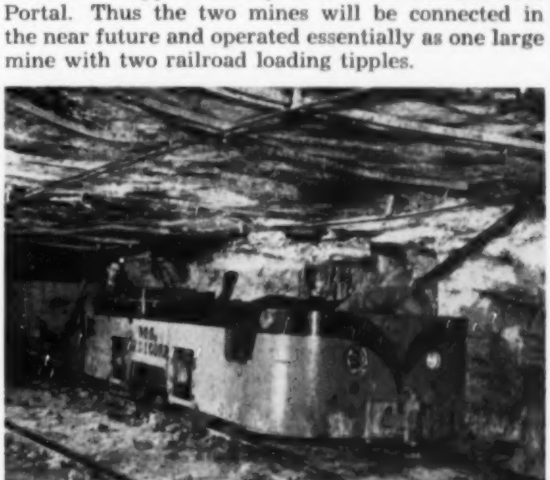
The layout at the bottom of the East Portal slope includes a modern system for transferring the coal and rock from mine cars to the big 48-in. belt. Coal and rock are hauled to the belt slope in 8-ton, drop-bottom cars and dumped automatically into either a 100-ton rock bin, or a 200-ton coal bin. Bins have vertical sides, with the bottom tapering at 45°. Two vibrating feeders, one at the coal bin, and one at the rock bin, discharge onto a 48-in., 8-ply *shock* belt 70 ft long. This belt absorbs the initial impact of coal or rock, and conveys material to the transfer point where it is fed to the main slope belt for the trip to the surface. The large concrete and steel pocket which houses the rock and coal bins, feeders, shock belt, drives and sump is 118x18 ft, and it is 56 ft from top of rail at dump to the floor.

An important feature of the protection of the large belt is a magnetic installation for the detection of metal materials. The shock belt travels over a set of magnets which are electrically arranged to stop the shock belt and sound an alarm when activated by the presence of drill steel, roof bolts, or other metal objects in either the coal or rock.

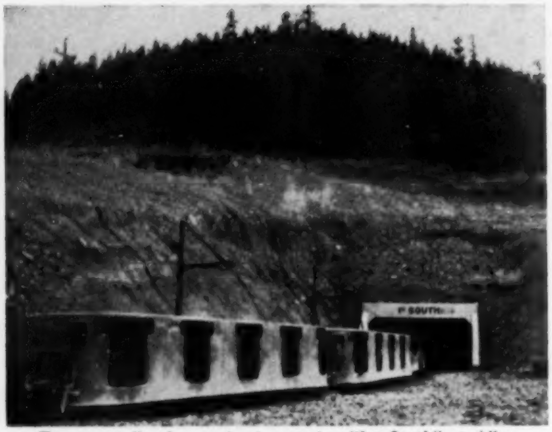
Seven parallel main slope entries on 70-ft centers will be driven east from the West Portal to meet seven raise entries driven west from the East Portal. These seven main entries will be continued for a distance of approximately 6000 ft east of the East Portal. Thus the two mines will be connected in the near future and operated essentially as one large mine with two railroad loading tipples.



This 48 in. belt with a capacity of 700 tons per hr operates between mine portal and breaker house at the East Portal. Rock brought out is diverted into a 100 ton bin.



Ten ton trolley locomotive hauls train of cars on a main entry at the Allen mine. Roof supports consist of channels bolted against the roof by split rod and wedge type bolts.



Ten-ton trolley locomotive is entering "1st South" at Allen mine. Modern and comfortable transportation facilities cut down travel time necessary to haul crews to and from working places.

North and south entries in multiples of five will be driven off these main entries on grade suitable for trolley locomotive hauling strings of drop-bottom mine cars. From these water-level entries, panel entries will be driven in sets of three, the center entry being equipped with a 30-in., 4-ply, belt conveyor. Maximum length of belt conveyors for use in panel entries is 1500 ft. Rooms will be driven from the panel entries by trackless mobile cutting and loading equipment, and shuttle car haulage, where the pitch of the seam does not exceed 10 pct. In the west portion of the mine, where the pitch of the seam exceeds 10 pct, shaking conveyors and shortwall cutting machines will be used. The mining system provides for complete extraction of pillars. Primary roof supports will consist of roof bolts of split rod and wedge type set at 4-ft intervals. Some secondary roof supports will consist of posts and three-piece timber sets placed principally in shaking conveyor work in rooms where wood supports serve to better advantage along the pan lines and the setting of roof jacks and timbers fits into the cycle of operations better than drilling and installing bolts.

The underground workings of Allen mine are entirely mechanized. Each step in the production cycle at the working faces has been studied to determine the most efficient and safest method possible to do the job. The men who operate these high-powered and high-capacity machines that mine the coal at Allen are all skilled workmen. A qualified section foreman certified by the State of Colorado is in charge of each mobile-loading district. At the beginning and end of the several operations of a cycle, the working place is examined carefully by a qualified person for bad roof, methane, and other dangers.

A different operating cycle is required in shaking conveyor work, where the coal is on a pitch of around 10 pct or more. While the equipment is of portable construction, it is not what is known as mobile. Shaking conveyor operations consist of driving a series of rooms to a distance of 300 ft and extracting the pillars with equipment—consisting of a shaking conveyor with duckbill loading head, short-wall cutting machine, electric post drill, and miscellaneous equipment—that remains in the working place from the time the place is started until it is finished. Upon completion of a working place, the shaking conveyor equipment is moved out and set up to start another room. The face conveyor crew does all the drilling, undercutting, blasting, and loading, extending the pan lines, and setting of roof supports. The conveyor coal is discharged onto the 30-in. panel belt conveyor. A roller switch on the panel belt stops the shaking conveyor when the belt is stopped or not operating at normal speed, or when it is operating in reverse, handling materials and supplies.

Each panel belt discharges its coal onto a reversible shuttle belt, termed a *yoyo*, set parallel to the haulageway, which, in turn, discharges the coal into the mine cars without any spillage.

The Mobile-Loading Cycle

1. A portable air compressor on pneumatic tires operated by electric power transmitted through a trailing cable from a power distribution center is brought into the working place by two drillers and roof bolters. Drilling equipment consisting of stoper, impact wrench, drill steel, and pneumatic dust collector, and an air-driven coal drill and auger, along with roof bolting materials, are carried on the air compressor. The stoper and impact wrench are used in roof bolting, and the air drill and auger are used in drilling shot holes in the coal. After the roof jacks and temporary timbers have been removed and the roof securely supported by bolts, and the shot holes drilled, the drillers and roof bolters load up their equipment and supplies and move their compressor to an adjoining working place to continue with the same operations there.
2. A large universal cutting machine is the next step in the coal production cycle. It travels on pneumatic tires and also gets its electric power through a trailing cable. This machine makes a 9½ ft horizontal and vertical cut in the coal seam, and then moves out to make way for the shotfirers who blast the coal. Water is kept on the cutter bar during cutting operations in order to allay the coal dust.
3. The several holes in the working face are charged with a Bureau of Mines permissible powder and thoroughly tamped to the mouth of the holes and detonated by a Government-approved blasting machine using electric blasting caps consisting of one instantaneous cap and 1st, 2nd, and 3rd delays.
4. When the shotfirers finish blasting, they move on to another working place and the mobile loading machine moves in to load out the coal that has just recently been shot down. The loading machine is mounted on caterpillar treads, and it gets its electric power through trailing cables from the power distribution center. The loading machine has a capacity of 10 tons per minute, and with its gathering arms scoops up the freshly shot coal and conveys it into a waiting shuttle car. Two shuttle cars are required for each loading machine, and they carry about 4 tons of coal each. They are powered through trailing cables and are mounted on pneumatic tires. The one-way haul from the loading machine to the panel belt or loading ramp into mine cars is limited to about 300 ft. After the coal is loaded out, the cycle starts over again, beginning with the first step of installing roof bolts and drilling shot holes in the coal. The loading machine crew, along with help from timbermen, set roof jacks and temporary posts when needed during loading operations. A novel feature is the use of water instead of air in underground mining and loading equipment tires, thereby materially lengthening their life. Supplies and materials in mobile loading sections are handled by small, rubber-tired tractors powered by storage batteries and equipped with trailers.

Here is some of the equipment required for a modern, mechanized coal mine

Cutting machines, 11-RU, 9 ft cutter bar, water-filled dual tires	Joy Mfg. Co.
Cutting machine, type 512 EL 3, shortwall, 9 ft 6 in. cutter bar & bugduster	Goodman Mfg. Co.
Cutting machine truck, T2-5, caterpillar mounted	Joy Mfg. Co.
Cutting machine bits, conventional type* on mobile equipment, Throwaway type (*Haystellite-tipped at mine)	Colorado Fuel & Iron Corp. Goodman Mfg. Co.
Electric coal drills, No. 574, post-mounted	Chicago Pneumatic Tool Co.
Flexible shaft coal drills, driven from mechanical power take-off on cutting machines, hand-held	Crichton Co., Johnstown, Pa.
Pneumatic coal augers, 33J4, hand-held	Ingersoll-Rand Co.
Drill bits for CP drill, No. 574, Sulmet, RD 2¼ in.	Joy Mfg. Co.
Drill bits for pneumatic and flexible shaft, hand-held, coal augers, Sulmet, RD 2¼ in.	Joy Mfg. Co.
Impact wrench	Ingersoll-Rand Co.
Stopers and jackhammers	Ingersoll-Rand Co.
Drill bits for stopers and jackhammers, 1½ in., 1⅜ in. and 1¼ in., Liddicoat	Western Rock Bit Mfg. Co.
Explosives for blasting coal, Duobel C, 1½ x 8	E. I. duPont de Nemours & Co.
Explosives for blasting rock, Gelobel C, 1¼ x 8	E. I. duPont de Nemours & Co.
Igniters, electric, instantaneous and 1st to 4th delays	Hercules Powder Co.
Shot-firing machine, 10-shot	Farmers Electric Mfg. Co.
Portable extension roof jacks, MR-16	Duff-Norton Mfg. Co.
Loading machines, 660-C, tractor tread	Goodman Mfg. Co.
Belt conveyors	Link Belt Co. Goodman Mfg. Co. Chain Belt Co.
Belts for conveyors	U. S. Rubber Co.
Electric motors	Westinghouse Electric & Mfg. Co. General Electric Co. Reliance Electric & Eng. Co. Allis-Chalmers Mfg. Co.
Shaker conveyors, L-20 drive, No. 1½ troughs, duckbill	Goodman Mfg. Co.
Chain conveyors, WT-15, "Long"	Goodman Mfg. Co.
Mine cars, 8-ton, 7 ft wide and 18 ft 5 in. long	Allison Steel Co.
Mine car bearings, tapered roller	Timken Roller Bearing Co.
Mine car wheels	Card Iron Works
Supply cars, 20-ton capacity, 18 ft. 8 in. long x 6 ft 1 in. wide	Differential Steel Car Co.
Mantrip cars, 38-passenger	Differential Steel Car Co.
Couplers, all cars, automatic, Willison	National Malleable & Steel Castings Co.
Mine car hoists, CHD	Joy Mfg. Co.
Phillips shuttle car carriers, 20-ton	Joy Mfg. Co.
Shuttle cars, 6SC, 21 ft 9¾ in. long x 7 ft 4½ in. wide	Joy Mfg. Co.
Tires for shuttle cars, 8:25 x 15, hard rock, water-filled lug tires	Goodyear Tire & Rubber Co. Goodrich Tire & Rubber Co.
Locomotives, 10-ton, 75 hp	Goodman Mfg. Co.
Equipment carriers, Phil-Dolly	Joy Mfg. Co.
Mine tractors, Exide battery	Baker-Rauling Co.
Utility trailers	J. H. Fletcher Co.
Rails, 45, 75, and 90 lb	Colorado Fuel & Iron Corp.
Track accessories	Colorado Fuel & Iron Corp.
Track turnouts	American Brake Shoe Co.
Creosoted cross ties	Koppers Co.
Trolley wire, 6-0, grooved	Chase Copper & Brass Co.
Trolley materials	Ohio Brass Co.
Trolley materials	Electric Railway Equipment Co. Cincinnati, Ohio
Rail bonds	Ohio Brass Co.
Electric cables	General Electric Anaconda Wire & Cable Co. Roebling
Shot-firing cables, No. 18, 2-cond.	Various Brands
Mercury arc rectifiers, 300 kw	Westinghouse Electric & Mfg. Co.
Selenium rectifier	Clark Electronic Laboratories
Underground transformers, 300 kva	Westinghouse Electric & Mfg. Co.
Safety circuit centers	Joy Mfg. Co.
Welding equipment	Lincoln Electric Co.
Rock dust distributors	Mines Safety Appliance Co.
Mine fans No. 12A-83, Aerodyne	Jeffrey Mfg. Co.
Mine fan auxiliary drives	Caterpillar Tractor Co.
Wire rope	Wickwire Spencer, Colo. Fuel & Iron Co.
Pumps, Type P	Weiman Pump Mfg. Co.
Pumps, centrifugal	Allis-Chalmers Mfg. Co.
Air Compressors, WK-83 WL-80 WL-60	Joy Mfg. Co.
Substations and power transformers	Allis-Chalmers Mfg. Co.
Surface lighting transformers	Westinghouse Electric & Mfg. Co.
Shaft & slope sinking	Utah Construction Co.
Preparation plants	McNally-Pittsburg Mfg. Co.
V brating feeders	Syntron Co.
Vibrating screen	Allis-Chalmers Mfg. Co.
Bradford breaker	Pennsylvania Crusher Co.
Railroad car droppers	McNally-Pittsburg Mfg. Co.
Railroad car pullers, HKD	Brown-Fayro Co.
Tramp iron detector	Industrial Physics & Electronics
Electric cap lamps, model R-4	Mines Safety Appliance Co.
Steam cleaner	Mines Safety Appliance Co.
Surface diesel locomotives, 15-ton	Davenport Besler Corp.
Waste trucks	Euclid Road Machinery Co.
Shop lathe	Lodge & Shipley Co.
Shop radial drill	Fosdick Machine Tool Co.
Shop crane	Harnischfeger Corp.
Yard crane, H-3 Hydrocrane	Bucyrus Erie
Steel water tanks	Columbia Steel Tank Co.
Bridge culverts	Armco Drainage & Metal Prod.
Overcasts	Armco Drainage & Metal Prod.
Dust collector, model D-4-S	United Engineers, Birmingham, Ala.
Cable fault finder, Cemco, model A	Gibralter Equipment Co.
Industrial buildings	Western Marketing Corp.
Safety lamp testing cabinet	Mines Safety Appliance Co.
Hydraulic press, model U-150-13, 150-ton, cyl. size 6½ x 13	Rodgers Hydraulic Inc.
Spike driver, C.P. 115	Stearns-Rogers Mfg. Co.
Jack legs for jackhammer, JL-4	Ingersoll-Rand Co.
TrolleyFone, 250 volt, D.C.	Mines Safety Appliance Co.
Boiler, Kewanee type C, 10,330 sq ft, steam rating for stoker firing	Crane O'Fallon Co.
Stoker, bin feed, Whiting, model 350-SL, Westinghouse 2 hp motor	Crane O'Fallon Co.
Boilers, Kewanee 7L83 type C, 10,000 sq ft steam rating for stoker firing	Crane O'Fallon Co.
Stokers, Iron Fireman, size PS-75, series 401, with GE 1 hp motor	Stephen & Lambert Plumbing & Heating, Pueblo, Colo.
Split rod & wedge type roof bolts, 1 in., with various types of washers	Colorado Fuel & Iron Corp.
Steel channels for roof supports, 4 in., 6.25 lb	Colorado Fuel & Iron Corp.
Safety goggles	American Optical Co.

Haulage

Primary haulage at Allen mine consists of a track system that includes the use of 8-ton, steel, drop-bottom mine cars equipped with automatic couplers and pulled by 10-ton locomotives operated in tandem except on the main slope haulageway at the West Portal, where the mine cars will be hauled to the surface by a 12,000-lb rope pull, single-drum hoist and a 1¼ in. haulage rope. Long range planning is again apparent in the construction of main haulageways. Track gauge is 48-in. Ninety-pound rails are laid on 6x6-in. by 6 ft 6-in. creosoted mine ties and manganese frogs are installed at all turnouts. Haulage entries are at least 14 ft wide and are graded to provide a minimum height of 6 ft over the rails, and ample side clearance is always maintained. On trolley motor roads, all joints are carefully bonded to preserve electrical conductivity. Trolley phones are used for communication between the locomotives and belt loading points, and to the surface hoist houses. No wood roof supports are in evidence on trolley locomotive or rope haulageways. The roof is securely bolted, and 4-in. channels, 12 ft long, are mainly used as bearing plates instead of the individual triangular pad under each bolt.

Roof Bolting

CF&I considers that roof bolting is one of the many great developments in the history of coal mining and first adopted this method of roof support in July 1949. Since then, 30 miles of entries have been supported at corporation mines by the split rod and wedge type bolts manufactured by CF&I at its Pueblo plant.

Plans provide for the installation of 150,000 roof bolts in corporation coal mines in 1953, equivalent to 28 miles of passageway. While roof bolting in entries with 4-in. channels as bearing plates has proven more costly than wood supports from an initial standpoint, the long-range program will re-

sult in a tremendous saving due to the fact that the high cost of retimbering because of the decay of wood, mainly in return air courses, will be practically eliminated.

Ventilation

Realizing the importance of adequate, dependable ventilation, two identical ventilating units have been installed at two vertical air shafts, one at the West Portal and one at the East Portal. Each air shaft is of concrete construction, 14 ft diam, and 40 and 400 ft deep respectively. Each shaft has a 7-ft diam, electrically-driven, Aerodyne fan operated exhausting, in fireproof housing, having a rating of 250,000 cfm, that will provide an ample volume of fresh air for the many separate air splits that will be required when the mine gets up to maximum production. An outstanding safety feature of the fan installations is the provision of an auxiliary drive for each of the fans. Should electric power be interrupted by storms or other causes, a diesel engine will automatically start, and drive the fan. Although normal mine operations will come to a halt upon the failure of electric power, a constant flow of fresh air will be possible by means of this auxiliary drive equipment for the fans.

Safety

Safety is a major consideration at Allen mine. New employees are instructed as to their job hazards upon employment. Work is not permitted until the employee has provided himself with proper work clothing, safety-toe shoes, hard hat, and safety goggles. Adequate clearances with respect to underground haulage and the careful guarding of electrical conductors is apparent throughout the mine. Standards are set up for roof supports, for both roof bolts and timbers, such standards being based on study of prevailing conditions and on experience. Rock dust is distributed by rock dusting machines, and the amount of rock dust distributed will approach 5 lb per ton of coal mined. Water is piped to all working places, and the coal is sprinkled in order to allay the coal dust made in cutting and loading operations at its source. Employees are transported in and out of the mine in modern enclosed 8-wheel man-trip cars, having a capacity of 38 men.

Electric Power And Distribution

Electric power is purchased from the Frontier Power Co., which built a 44 kv line from Trinidad, a distance of 30 miles, in order to serve this fully mechanized mine, where about 9 kwh will be required per ton of coal produced. The 44-kv power is stepped down by oil-cooled, hydrogen-sealed, 3-phase transformers installed near the entrances to the East and West Portals to 4160 v ac, for transmission underground by subway cable. Portable underground transformer stations of noninflammable liquid and air-cooled types at convenient points to the active workings reduce voltage to 400 v ac, 3-phase, 60-cycle, for face operations. All face equipment units are gasproof, dustproof, and moisture-proof, and of USBM-approved types. Shuttle cars and mine trolley locomotives are powered by 250-v dc current, supplied by 300 kw portable ignitron rectifier sets of 4160 ac input along with small selenium rectifiers of 30 kw capacity with input of 440 v ac. The grounded neutral system is used throughout the mine, and USBM-approved safety circuit centers are installed to supply electric power to all face equipment. Primary surface power is 440 v ac, stepped down from 44 kv.

Coal Preparation

The cleaning of all coking coal for the byproduct ovens is accomplished at CF&I's Minnequa plant at Pueblo, Colo. A relatively new washing plant has been installed, utilizing air-pulsated type jigs. This new washing equipment has replaced the previously employed Diester table equipment, and is designed for a capacity of 350 tons per hr.

The initial step in the preparation of coal for use in the byproduct coke ovens is an efficient blending of the various coals used by this corporation. A total of five mixing bins are provided for the purpose of storing the coal and permitting the coal to be blended prior to entering the washery. Coal from the blending bins is conveyed to the coal washery and is fed to the jig sluices. The coal is supposed to be 1½ in. x 0 in. in size; however, a degree of oversize is usually present. From the jig sluices, the coal is divided and enters two 3-compartment, 2-cell, air-operated jigs, during which operation the impurities are removed from the coal.

The clean coal is then dewatered and screened, with the +⅜ in. size being discharged into a crusher of a hammer-mill type. The −⅜ in. size coal is then routed to centrifugal driers. The fine sizes contained in the effluent from the centrifugal driers are further channeled to the Rupp-Franz vibrating filters or to the Bird filter with the filter cake joining the crushed clean coal for conveyance to the clean coal storage bins, from where it is further transported by conveyor belts to the byproduct coke ovens.

As previously stated, this cleaning plant has recently undergone a change in coal washing equipment. An outstanding feature of these improvements is the fact that the change-over was accomplished virtually without any loss of coal tonnage to the coke ovens.

Ore Preparation

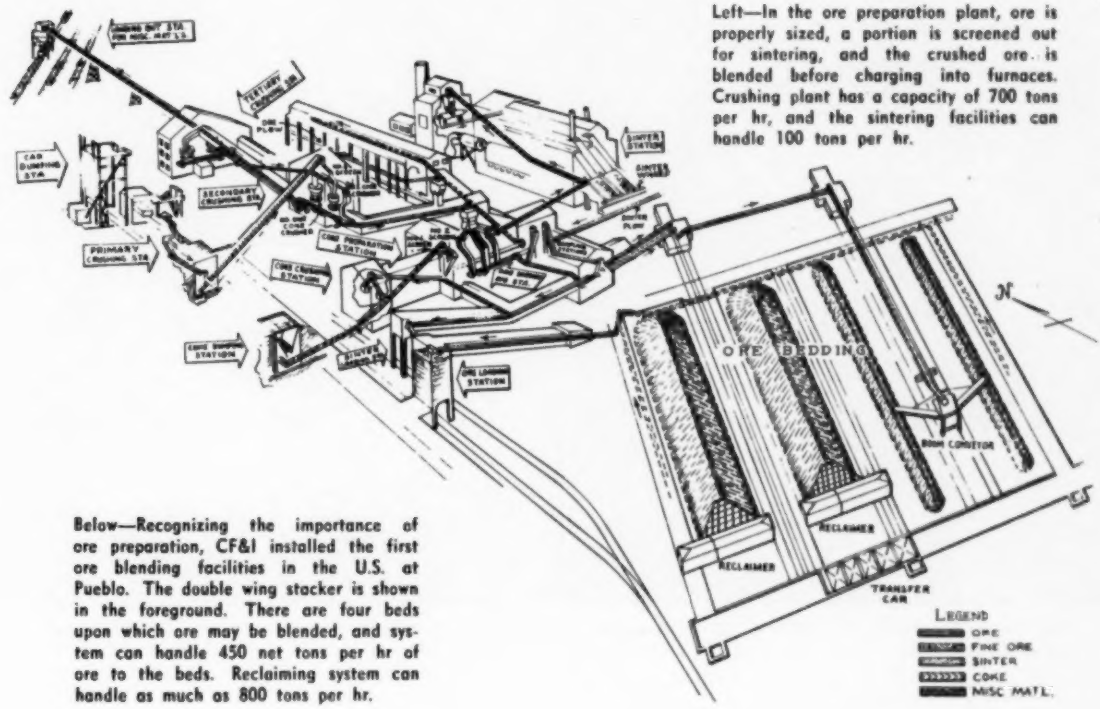
The Pueblo plant receives its principal supply of iron ore from the Sunrise mine, located in Platte County, Wyo., and Iron Mountain, southwest of Cedar City, Utah. Limestone from Monarch quarry located on the continental divide above Salida, Colo., is shipped into Pueblo to be used as a flux.

Of importance to the successful operation of the blast furnace plant is the ore preparation unit at Pueblo. Due to the geologic structure of both the Utah and Wyoming deposits, the ores, both high in grade, are quite variable in chemical and physical nature.

The Sunrise deposit has a border rock consisting of schists and irregular inclusions of pinite (hydrous silicate of aluminum potassium) in the orebodies. The principal variables in the ore are the iron and silica-alumina contents. Sunrise ore is, for the most part, soft hematite running about 22 pct −80 mesh.

The tonnage received from the Utah area has been from the Duncan and Blowout orebodies and varies from 20 to 100 pct magnetic. The ores are hard and vary chiefly in iron, silica, sulphur and phosphorus content.

Pueblo Ore Preparation Plant



Left—In the ore preparation plant, ore is properly sized, a portion is screened out for sintering, and the crushed ore is blended before charging into furnaces. Crushing plant has a capacity of 700 tons per hr, and the sintering facilities can handle 100 tons per hr.

Below—Recognizing the importance of ore preparation, CF&I installed the first ore blending facilities in the U.S. at Pueblo. The double wing stacker is shown in the foreground. There are four beds upon which ore may be blended, and system can handle 450 net tons per hr of ore to the beds. Reclaiming system can handle as much as 800 tons per hr.

Aerial view shows Richard ore mine and company houses at Wharton, N. J. This underground magnetite mine began as a surface pit operation in 1854.

CF&I Raw Materials

Eastern Operations

by Fordyce Coburn

RICHARD ore mine of the Colorado Fuel & Iron Corp. is an underground magnetite operation located in northern New Jersey approximately four miles northeast of the town of Dover, and 40 miles west of New York City. The mine is situated on the southeastern flank of one of the many gneissic ridges having a northeast-southwest trend.

The history of the Richard mine dates back to 1854 when mining was started from small surface pits. During the period from 1854 through 1916 a number of shafts were sunk to various depths. In 1917, a four compartment vertical shaft known as the Sweetser shaft was sunk by Thomas Iron Co. to a depth of 1230 ft. Over a period of years, the mine has changed ownership a number of times and has included the Philadelphia & Reading Coal & Iron Co., the E. & G. Brooke Iron Co., and the Colorado Fuel & Iron Corp.

The present capacity of the mine is approximately 1000 tons of crude ore hoisted daily with the mill averaging 640 tons of finished product daily. This product is presently divided as shown in the table:

FORDYCE COBURN, manager of eastern operations for CF&I, joined the E. & G. Brooke Iron Co. as vice president in 1944, and was named vice president of Richard Ore Co. in 1946.

Iron Ore Products at Richard Ore Mine

Ore Description	Fe, Pct	Production, Pct
Concentrates, —8 mesh, for sintering	65	67
XXX Crushed, —7/16 in., for sintering; Blast furnace crushed, —1¾ x +¼ in., for direct charging	61	28
Open hearth lump, —7 x +2 in.	60	5

The ore deposit is a magnetic iron ore occurring in the pre-Cambrian gneisses which conforms in general to the structure of the country rock. There are two vein systems, recognized locally as the North and South Veins. These veins dip from 30° to 55° to the southeast and have an average pitch of 15° to the northeast. The North Vein consists of three shoots or lenses having an average thickness

Plant Interrelationship

Operating units of CF&I in the eastern section of the U.S. form a production team with widely diversified products. Focal point of eastern operations is Buffalo, N. Y.

The Wickwire Spencer Steel div. consists of Brooke, Buffalo, Claymont, Clinton, Morgan, and Palmer plants. Also located in the east are two subsidiaries, American Wire Fabrics Corp., and John A. Roebling's Sons Corp.

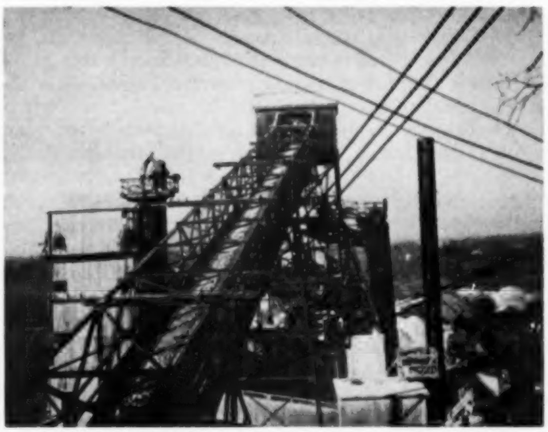
Ore from the Richard mine supplies blast furnace ore and sintering concentrates to the Brooke plant. This mine also supplies a portion of the blast furnace and open hearth ore to the Buffalo plant and supplies open hearth ore to the Claymont plant. The Brooke plant supplies pig iron to the Claymont plant and to the John A. Roebling's Sons Corp. subsidiary, as well as supplying a portion of the sinter needed at the Buffalo plant blast furnaces.

A management staff, set up at Buffalo, coordinates these interlocking operations, where one plant relies on another for smooth and efficient scheduling.

of approximately 11 ft which are joined by a small leader of ore ranging in width from a few inches up to several feet. The South Vein, which lies 300 ft in the hanging wall of the North Vein, consists of one shoot approximately 2400 ft long and varying in thickness from 8 to 40 ft.

Access to the mine is through the Sweetser shaft which is 1230 ft deep with the 1100 level being the lowest level. A 25° slope lying between the North and South Veins and 2000 ft northeast from the 1100 level Sweetser shaft station services the 1300 and 1500 levels. A modified shrinkage stope method of mining is used. Raises are driven from level to level on 75 ft centers with the stope chutes on 25 ft centers. Sublevels varying in length from 10 to 15 ft and driven at 20 to 30 ft intervals are used as entrances into the stopes. Drift floor pillars, 25 ft deep, are left in each stope. After the broken ore has been removed from the stopes, the raise pillars between the stopes and the drift floor pillars and chute pillars from the upper level are removed.

There are 249 employees on the plant payroll. This includes all phases of office, surface, mill, and underground operations. Of this number, 148 are employed on three shifts in the mine, 38 in the mill, and the remainder in the office, surface and maintenance dept. A town site of 31 duplex houses and including recreational and social facilities is maintained by the corporation for its employees and their children. Labor relations are excellent.



Inclined rubber belt conveyor moves stone from crusher to top of separation building at Gasport quarry. Stone sifts by gravity through a series of diminishing screens and chutes into proper bins.

Gasport Quarry

The Gasport, N. Y., quarry has been supplying dolomite products both to the Wickwire Spencer Steel div. at Buffalo, and to the local community areas continuously since 1913. Prior to that time in 1910, it provided ballast stone for the Buffalo, Lockport, & Rochester Ry. Co., a local trolley-car line then in the process of construction. The trolley line project lasted about a year, after which the quarry closed down for three years, until its acquisition by the Buffalo plant. The area covered by the quarry and its yard facilities is about 115 acres.

At the present time, about 35 acres have been worked down to the shale stratum which has varied from an initial depth of 12 ft to the present 30 ft level. The rock strata slope to the southeast and the quarrying has moved in a generally west-to-east direction. Today's operations are proceeding at the rate of an acre of stone per year, a quantity approaching 100,000 net tons.

The crushed product is obtained by the *open-face* method. The irregular topsoil layer, of from 0 to 18 in. in depth, is stripped from the stone and 6 in. diam holes, 30 ft deep and 10 ft back from the shelf are drilled at distances of 12 ft apart. Staggered rows of holes, at 10-ft intervals, follow the first row until a desired number are ready for charging. Dynamite sticks of 4½ in. diam, 200 lb per hole,

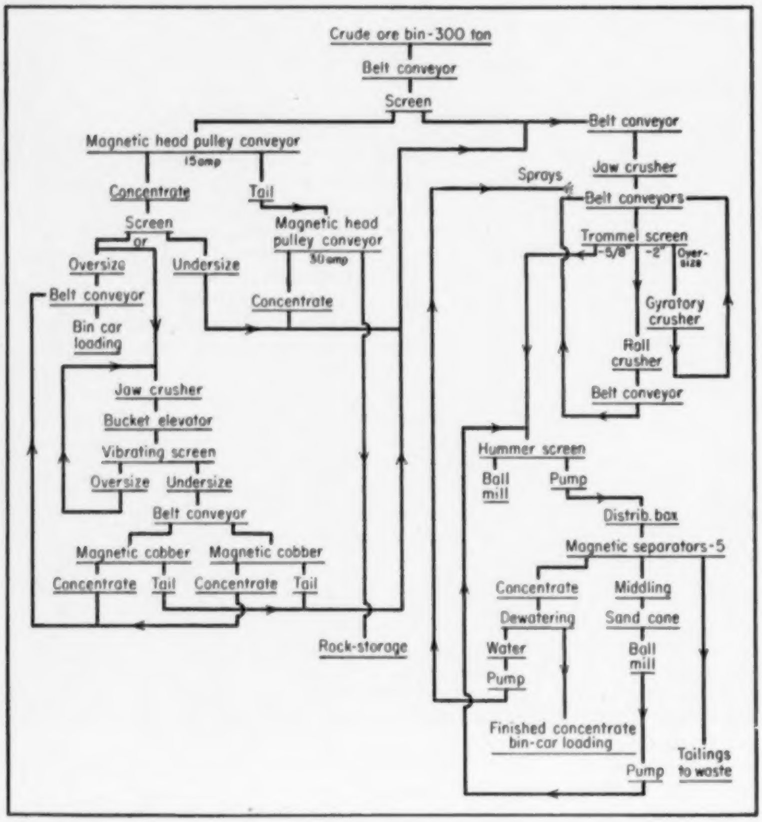
Stone Sizes and Their Uses

No.	Size, In.	Uses
0	0 to ¼	Agricultural fertilizer, screenings, filler
1A	⅛ to ¼	Oilstone
1	¼ to ½	Open hearth raw dolomite, oilstone for roads
2	½ to 1	Concrete aggregate
3A	1 to 1⅞	Crushed stone roads, concrete aggregate
3	1 to 2¼	Crushed stone roads, concrete aggregate
4	2¼ to 3¼	Crushed stone roads, concrete aggregate
5	3¼ to 4	Blast furnace stone (flux)

are then loaded and set off as directed. Power shovels load the blasted stone into trucks which carry it to the crusher. The crusher breaks up chunks as large as 2 tons each, first to coconut size, then to fist size, after which the stone is passed onto an inclined rubber belt conveyor. The sizes mentioned are maximums, with particle sizes ranging downward to the point where they can pass through a 20-mesh screen.

The total mass is then transported on the conveyor to the top of the bagging and storage building, where it sifts by gravity through a series of diminishing screens and chutes into its proper bins. From the bins it is bagged or removed to storage piles adjacent to the building. The eight stone sizes which comprise those most in demand and some of their uses are given in the table above.

The No. 0 agricultural mix is bagged and transported to local farms. Road and concrete stone is delivered where needed and the open hearth and blast furnace fluxes are sent on to the Buffalo plant. Assuming 100,000 net tons annual production, the distribution of the stone product is roughly 15 pct for agricultural uses, 20 pct open hearth, 25 pct



Flow sheet shows operations at Richard ore mine. Capacity of the mine is 1000 tons of crude ore daily, and the mill averages 640 tons of finished product daily. The plant furnishes 60 pct of the concentrates used in the E. & G. Brooke sintering plant. Open hearth lump ore is shipped to the corporation's furnaces at Buffalo, Claymont, and Roebling.

blast furnace and 40 pct for all other commercial road and concrete uses.

Purchased Iron Ore and Coke

Production of high quality pig iron and steel in the Eastern plants of the corporation results from the careful blending of good basic raw materials, such as iron ore, limestone, coke, and purchased steel scrap. A rigid standard of quality in raw materials is maintained by careful analysis of all receipts prior to use by either the blast furnace or open hearth.

At the two Buffalo blast furnaces, hematite iron ores from the upper Great Lakes are mixed with smaller amounts of crushed domestic and Canadian magnetite ore and high iron New Jersey magnetite concentrates sintered in eastern Pennsylvania at the corporation's Brooke plant. Limestone is used in the ratio of 80 pct calcite from upper Michigan and 20 pct dolomite from the Gasport quarry. Blast furnace fuel at Buffalo is byproduct coke screened and shipped daily in two sizes (blast furnace and nut grades) from a supplier in the Buffalo district. The physical and chemical characteristics of the coke are checked daily.

The Brooke blast furnace operates with 60 to 65 pct of its ore burden in the form of sintered iron ores, chiefly magnetite concentrates from northern New Jersey, where Richard ore mine supplies 60 pct of the concentrates used in the Brooke sintering plant. The balance of the domestic concentrates required at the Brooke sintering plant are purchased from another company whose property adjoins the Richard mine. Due to low flue dust production at the Brooke blast furnace, additional flue dust is purchased for blending with anthracite No. 4 buckwheat coal to provide the best possible combination of fuel and high yield for the feed ore mixture to the sintering machine. When there is a demand for the production of certain grades of low phosphorus pig iron, a special low phosphorus iron ore concentrate is imported from West Africa and is either sintered alone or is blended as a diluent with small amounts of the higher phosphorus domestic concentrates. Manganiferous iron ore fines are also imported from Egypt for the production of high manganese sinters. A small tonnage of siliceous Lake ore is shipped to the Brooke plant during navigation season by boat and rail through the port of Erie, Pa.

Limestone, in the ratio of 80 pct calcite and 20 pct dolomite is shipped by rail from local quarries within 25 miles of the plant. Fuel for the furnace is byproduct coke screened and shipped daily in blast furnace and nut grades from a supplier in the Philadelphia district. Other raw materials, such as mill scale, cinder, open hearth slag, and short shoveling turnings are normally shipped to the Brooke furnace from within a 100-mile radius of the plant.

Open hearth lump ore is shipped by rail from the Richard ore mine to the corporation's open hearth furnaces at Buffalo, Claymont, and Roebling.

CF&I has expanded its Eastern operations to include plants located on either inland waterways, or on navigable tidewater tributaries, or within short rail hauls of major Atlantic east coast terminals, thus enabling these plants to utilize Canadian and other imported iron ores for blending advantageously with domestic ores to produce uniformly high quality pig iron and steel.

Process Development and Practice of the Potash Division of the Duval Sulphur and Potash Co.

by G. E. Atwood and D. J. Bourne

The new potash refinery of Duval Sulphur & Potash Co. produced its first tonnage of muriate of potash in November 1951. Full capacity was attained in early 1952. Excellent extraction efficiency is being obtained by the process, which is basically froth flotation. System temperature control is practiced and has proved to be of great metallurgical value through high potassium recovery and low reagent cost.

WHEN Duval Sulphur and Potash Co. recently entered the established potash industry, the vast amount of pioneer work essential in an entirely new endeavor was unnecessary. Thus it was possible to screen and assemble proved techniques into a highly efficient process based on the combined knowledge of the industry. It is hoped that the refinements Duval has added to these cumulative achievements will contribute to the rapid advance of the potash industry and related enterprises.

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The process selected utilizes as raw material sylvinite ore typical of the Permian Basin. This ore is principally comprised of interlocked crystals of potassium chloride, about 40 pct, and sodium chloride. Also there is as much as 1½ pct of dispersed clay slime which, because of its nature, highly complicates beneficiation of these ores. The refining method is basically flotation in which the mineral sylvite is floated away from the halite-clay gangue to produce a 60 pct K_2O muriate of potash product for the plant-food trade. It departs from established practice in the use of an improved reagent scheme, developed by the company's technical staff, and in

The Transactions papers appearing in Mining Engineering during 1953 will subsequently appear in AIME Transactions Vol. 196 and may be permanently referenced to that volume.

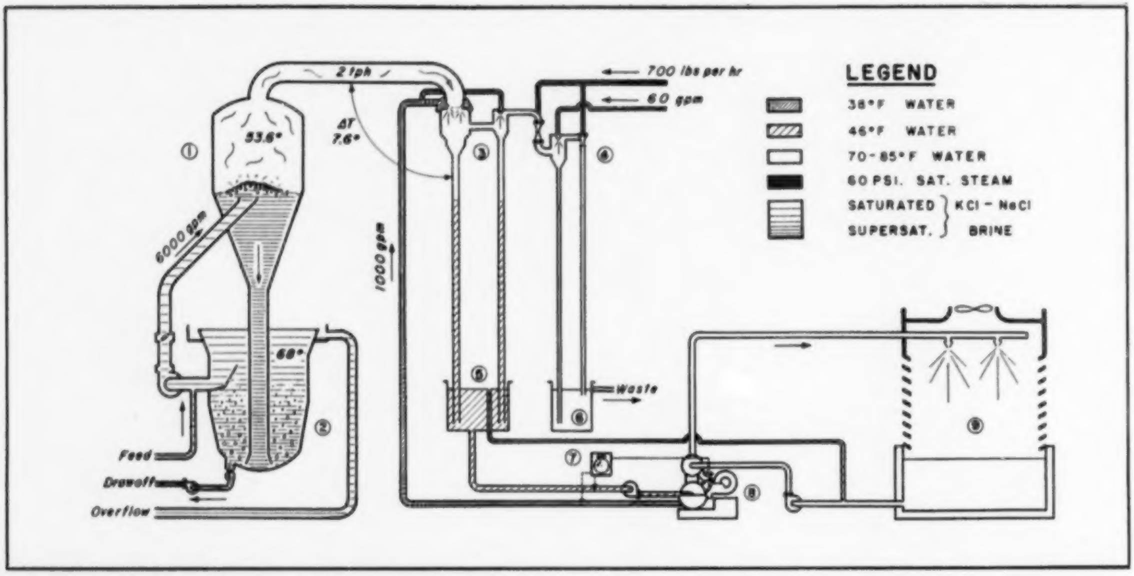

Fig. 1—Krystal flow diagram. Brine feed of 252 tph at 78°F enters the circulating line where it is pumped to the vaporizer (1). Following controlled vapor release, the supersaturated liquor passes to the suspension chamber (2). Crystal production of 2.3 tph is removed in a pulp with 7.7 tph of brine at the drawoff. Chilled brine overflow is 240 tph at 68°F. Vapor and non-condensible gas are respectively condensed and purged in a barometric condenser (3) and the two-stage ejector (4). Vessels (5) and (6) serve as the cold and hot wells. Chilled water for vapor condensation is provided by the Carrier centrifugal refrigeration machine (8), with refrigeration output controlled by the Foxboro temperature relation controller (7) actuating the suction damper to the compressor. Marley cooling tower (9) provides 70° water for condensing the refrigerant, Freon 11.

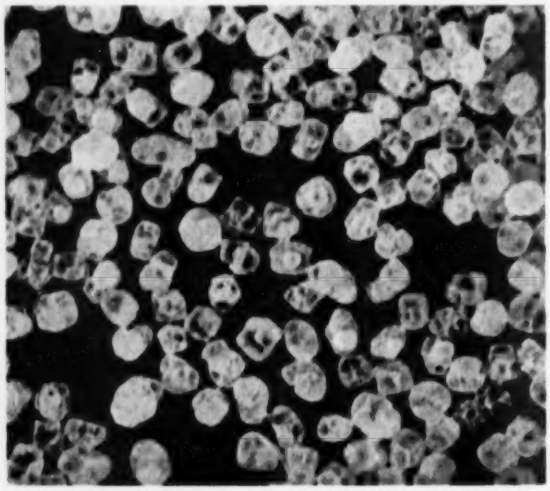

Fig. 2—The uniformity of crystals made possible by the Struthers-Wells Krystal vacuum crystallizer is illustrated above.

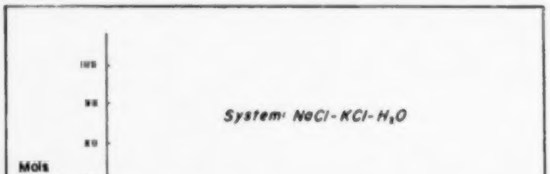

Fig. 3—Sylvite ore solubility data.

the unique manner in which temperature control is practiced.

The obvious importance of temperature in beneficiation of soluble ores dates from early solution and crystallization practice. To a somewhat lesser extent, yet still highly significant, is its effect during collection by flotation reagents. Since the process chosen embodies both flotation and crystallization, system temperature control was incorporated as a basic feature. The physical scheme of control is that of removing a fixed amount of heat from the system at one point while introducing a variable quantity at another. Heat supply is varied to provide optimum temperature of the overall system and constitutes a balance with the effects of a widely varying ambient temperature on 1¼ million gallons of brine in the closed circuit.

Constant heat withdrawal is accomplished by a Struthers-Wells Krystal vacuum crystallizer. Vapor and non-condensible gases from the Krystal vaporizer are respectively condensed and purged by a chilled-water, multi-spray, barometric condenser and two-stage Schutte-Koerting ejector. Chilled water for vapor condensation is provided by a Carrier centrifugal refrigeration machine rated at 333 tons per day. A general flow diagram of the installation is seen in Fig. 1.

Selection of the Krystal to release heat from a saturated NaCl-KCl brine was based entirely on its inherent capacity to yield a product of desired physical quality. This is thought to be the first application of the unit on potassium chloride in

this country, and its efficiency is evidenced by an hourly production of 2.3 tons of +28 mesh high-purity product.

The Krystal superiority arises from the adroit manner in which the widely-known principles of crystallization are simply applied. These principles[1] are reviewed as follows in the light of their application to this unit. The driving force necessary for both crystal formation and growth is defined as supersaturation. The degree of supersaturation may be divided into the metastable and labile fields. The former describes a temperature concentration relationship where crystallization occurs only on seed or nuclei already present. The labile field is supersaturation above metastability wherein spontaneous formation of new crystals occurs without the stimulation of seed or nuclei. Design features of the Krystal[2] are such that solution feed is maintained within the metastable field where crystal growth can be controlled. This is accomplished by 1—providing proper circulation rates through the vaporizer to hold supersaturation to the desired degree and 2—maintaining a dense bed of crystals in the suspension chamber adequate to remove supersaturation so produced. It can be noted in Fig. 1 that the liquor movement is downward from the vaporizer and upward through the crystal suspension. A classifying action is effected by the ascending flow, and only the finished crystals of desired size approach the draw-off. Hence varying the rate of draw-off, within the limits of capacity, results in mesh control. The uniformity of product is apparent in Fig. 2. The crystals are conducted to the drying section of the plant, where they are mixed with flotation concentrate adding both physical and chemical quality to the product.

To refer again to Fig. 1, the data presented reflect typical operation and heat balance for the section. The aim in the design of the section was to maintain a plant brine temperature of from 20° to 25°C. This target seemed practical from the standpoint of year-round ambient temperature variation, corrosion considerations, efficacy of flotation reagents, and phase relations in the NaCl, KCl, H_2O system. To produce the relatively cold brine necessary to hold the plant circuit at 20°C the Krystal operates at from 0.3 to 0.4 in. Hg absolute in the vaporizer. Vapor temperature plus a boiling point rise gives the brine temperature indicated, and vapor temperature less the terminal drop across the condenser necessary to drive the reaction at the capacity desired will give the indicated chilled water return temperature. Overload and icing protection on the chilled water circuit is provided by the Foxboro temperature-relation controller. Simple, safe, and efficient refrigeration is supplied by the compact Carrier centrifugal compressor. It is equipped with a suction damper air-operated by the controller.

Application of crystallization to NaCl-KCl brines has been practiced for many years. The compatibility of process with system is apparent from a glance at the phase data. Fig. 3 is the system KCl, NaCl, and water.[8] The solubility of potassium chloride decreases rapidly with temperature reduction, while sodium chloride varies but slightly over a wide temperature range and is in retrograde below 95°C.

Thus the saturated brines below 95°C lend themselves nicely to vacuum crystallization. In this range, slight increases in solubility tend to offset

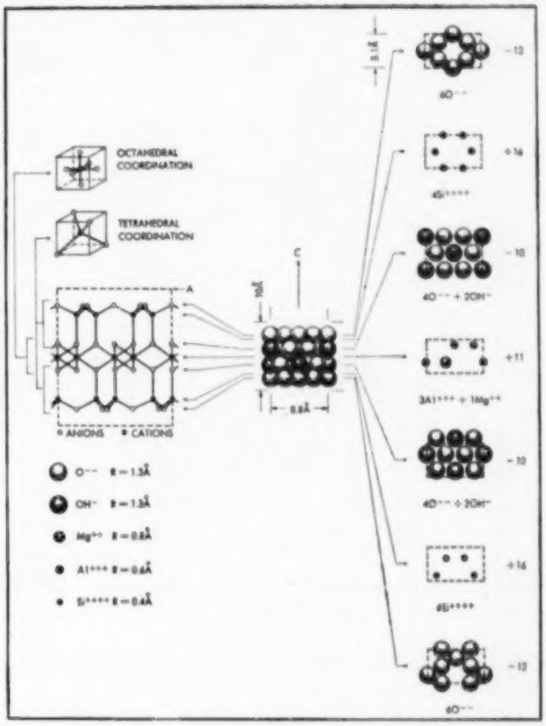

Fig. 4—The structure of montmorillonite 2 [($Al_{1.67}Mg_{0.33}$) Si_4O_{10} $(OH)_2$]. (After F. H. Norton, *Elements of Ceramics*, 1952.[8]

sodium supersaturation caused by vapor removal. This salient feature assures sodium-free potassium chloride crystals. Throughout all ranges a high yield of potassium per degree of temperature reduction is apparent from the slope of the saturation curve.

On the basis of these factors the effect of heat applied to a suspension of ore constituents in brine can be predicted. Accordingly all control heat is introduced to plant tailings just prior to filtration. In this manner any solid phase potassium values that have escaped the flotation section are dissolved

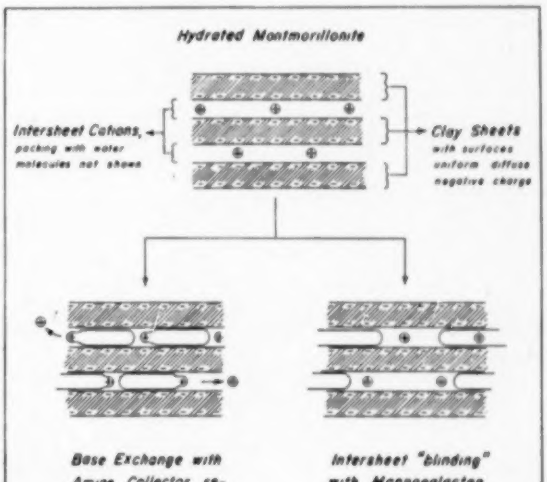

Fig. 5—The formation of montmorillonite complexes.

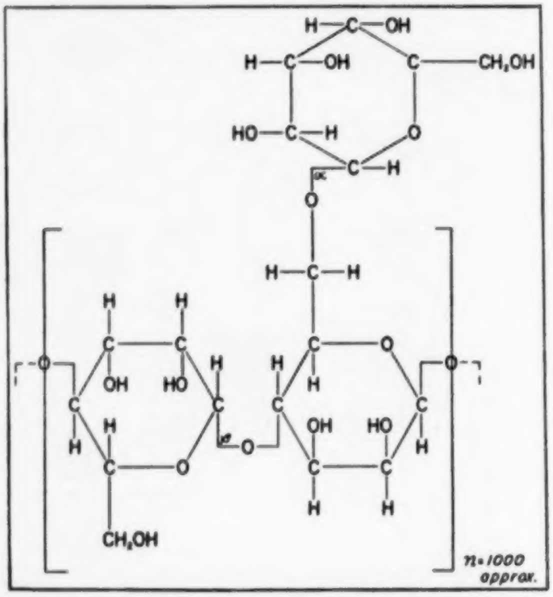

Fig. 6—The structural configuration of the unit cell of guar.

and are retained in the system for ultimate harvest in the Krystal.

Flotation recovery under these controlled temperature conditions is excellent and depends only slightly on secondary Krystal production for overall high process efficiency. A primary aliphatic amine salt manufactured from beef tallow is employed as the frothing and sylvite-collecting agent. The use of cationic agents in mineral flotation, though developed to a high degree, presents many complex problems with clay-bearing ores. To evaluate the adverse effect of clay slimes, it is necessary to have a clear understanding of their behavior and structural features.[4]

The clay associated with the Carlsbad ores has been identified as a member of the montmorillonite group. The approximate crystal structure of montmorillonite was suggested by Hoffman, Endell, and Wilm, and their work has been generously augmented by Hendricks, Bradley, McEwan, and others. The configuration generally accepted for the unit cell is shown in Fig. 4, outlined by dotted lines. The montmorillonite crystal is built from sheets of unit cells superposed one upon the other and held together by relatively weak forces. The oxygen-to-oxygen distance normal to, or separating the sheets, is variable from about 0.5 to 12A and depends upon conditions of exposure.

The basic pattern in the unit cell is the four-high packing of oxygen and hydroxyl ions coordinated about three layers of cations. The upper and lower cation layers consist of silicon tetrahedrally coordinated with oxygen. The central layer is aluminum octahedrally coordinated with hydroxyl and oxygen.

Occasional substitution of lesser-valent cations in either of the coordination positions results in a residual negative charge for the unit cell. In montmorillonite, the residual charge arises in the main from substitution of magnesium, and sometimes iron, for aluminum in the octahedral coordination position. In Fig. 4 note Norton's substitution of one magnesium for an aluminum ion in the central cation layer.[5] A net negative charge is arrived at by totaling the valence charges in the pictured cell. This electrostatic charge is balanced by the presence of replaceable intersheet ions and accounts for the high base exchange capacity peculiar to this particular clay. In addition, the montmorillonite adsorbs water and some neutral organic compounds binding them with relatively weak forces, probably Van der Waals. Normally, montmorillonite has two or more intersheet layers of water molecules loosely held in a more or less regular pattern. These molecules are two-dimensionally fluid and offer little or no interference to the free movement of intersheet exchange ions. An accepted *ease of replacement* series for these intersheet exchange ions shows: large organic cations >, H^+>, Ca^{++}>, Mg^{++}>, K^+>, Na^+;[6] thus the avid appetite of this clay for an aliphatic amine can be appreciated.

In hydrated montmorillonite, the intersheet spacing is sufficiently extended to pass readily large organic molecules which in turn displace the adsorbed water. Organic molecules on entering the clay crystal organize themselves for maximum utilization of the intersheet space, lying flat along the sheet surface and parallel to it, often in multiple layers. Hendricks[6] reports that the total surface of water sorption by this clay is about 8 million square centimeters per gram, which is in the order of 50 times the observed external surface. Clay crystals are normally 0.2 to 0.5 square microns in the basal plane, and contain from 50 to 100 silicate layers. In relating these characteristics to typical plant operation, it is found in the flotation feed, in spite of efficient desliming, the ratio of active clay surface to KCl surface is greater than 2000 to 1.

A calculation based on ion exchange capacity of the montmorillonite of 0.85 me per gram indicates that this quantity of clay would consume 1300 lb of amine per day, or ½ lb per ton of ore feed. This figure can be supported from sorptive area and net charge per unit cell calculations. It is this coupling of the appetite and the capacity of the clay for the flotation collector that poses a major metallurgical problem in the process.

In as much as mechanical desliming methods are not perfect, the solution of the problem must arise

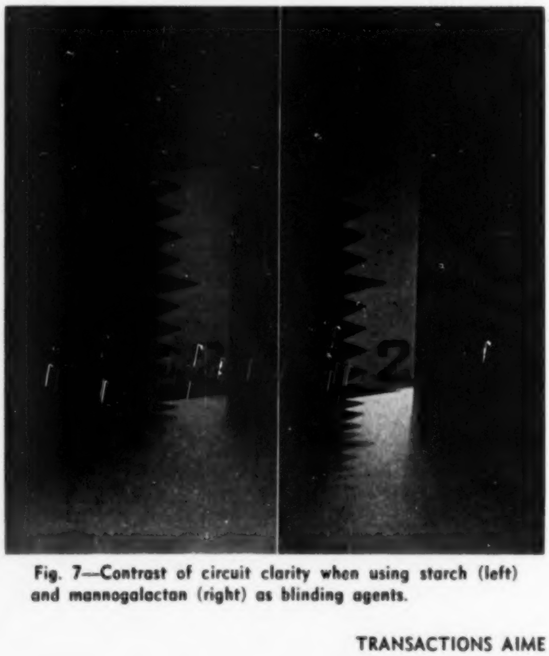

Fig. 7—Contrast of circuit clarity when using starch (left) and mannogalactan (right) as blinding agents.

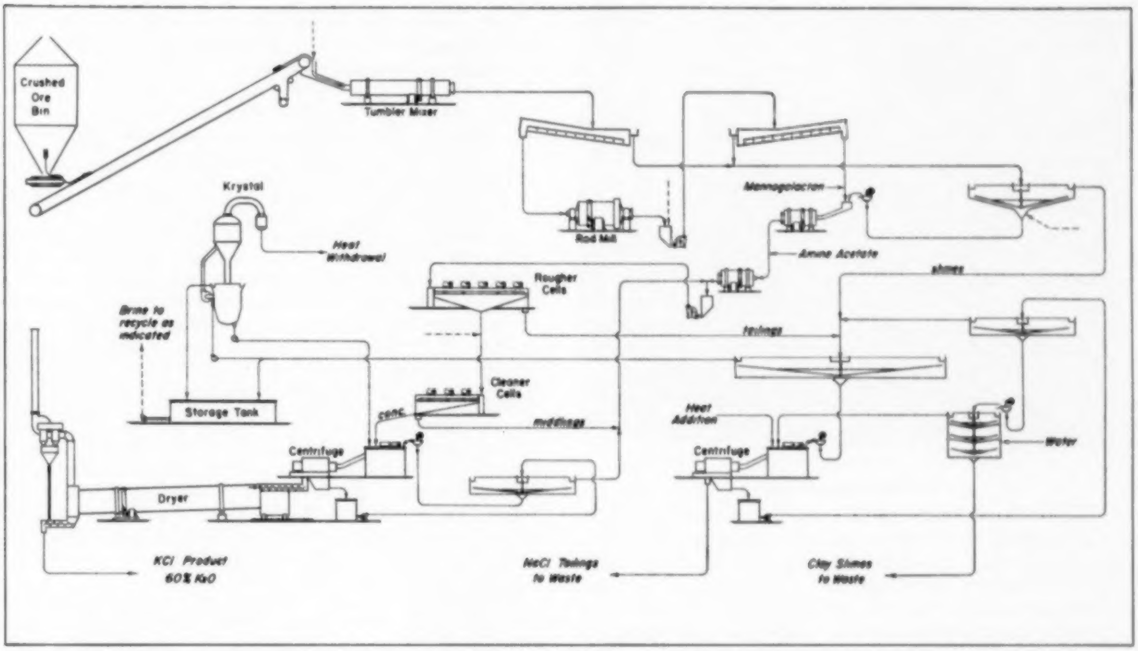

Fig. 8—The refinery flow diagram above shows the adaptation of the Krystal unit and the conditioning technique applied to mannogalactan.

from successful treatment of the unremoved clay. Effective treatment need not be permanent but must apply as long as the montmorillonite is in competition with the KCl crystal surface for the amine collector, i.e., while the flotation reaction is occurring. There appear to the authors at least three approaches to clay treatment:

1—Closing the sheets by irreversible dehydration with heat treatment. Heat-treated montmorillonite assumes a stable water-free configuration with less than 1 A intersheet spacing. This contracted crystal structure could not then pass the amine radical in base exchange. This solution seems prohibitive from the standpoint of economy, and there is, in addition, the acute danger of fusing the chloride ore salts during heat treatment.

2—Fixing the base exchange ion with a radical of sufficient activity and tenacity to preclude exchange with the amine collector. Though this possibility is still under investigation, its feasibility is hinged on the unit cost of a reagent of this category and possible interference with potash collection by the amine.

3—Blinding the structural interstices of the montmorillonite prior to the addition of the cationic collector. This method of treatment has found application in the mineral dressing industry, and its class of reagents are often referred to as depressants, or auxiliary agents. However, it is felt by the authors that the term *blinding agent* is more descriptive of the action in this particular instance. This scheme of clay control was selected for the Duval process.

In tailoring a blinding agent for the process, numerous characteristics are important, see Fig. 5. The reagent must be extremely compatible with the adsorptive surface of the montmorillonite, hence a hydrophilic or hydroxyl-laden molecule. Molecular structure should be non-anionic to prevent electrostatic interference. Configuration of the reagent must permit easy access between the clay sheets when they are normally extended by hydration. Individual attractive forces will at best be relatively weak; therefore the molecule should be as large as possible so that a mass bonding effect will be obtained. Additionally, high molecular weight, long-chain molecules, by virtue of their protruding bulk, could temporarily armor the clay particle against penetration by the cationic collector. Hydroxyl configuration should be such that the free groups are cis, thus augmenting the weak bonding forces by chelation as suggested to the authors by A. M. Gaudin. From the practical and operational standpoint, the material should be cheap, naturally-occurring, and of dependable quality and quantity.

Fulfillment of these specifications is amply satisfied by the reserve polysaccharide mannogalactan found in the endosperm of several pod-bearing legumes. The actual product in use[7] is General Mills' *guar*, milled from domestic supply. The configuration is postulated by Whistler and Smith to be a straight chain of D-mannopyranose units joined by β D-1, 4' linkages, with every other unit, on the average, bearing a side chain of one D-galactopyranose residue connected by an α D-1, 6' linkage. This configuration is pictured in Fig. 6. Molecular weight is estimated variously up to 500,000, which would yield a molecule of approximately one micron in length. It is interesting to note that this is larger than the average montmorillonite clay crystal. Again, using Hendricks' figure of 8 million square centimeters of sorptive area per gram of clay, the addition of 1.5 lb of guar per ton of ore feed would give complete initial coverage of all clay surface present in the flotation feed. In as much as one-tenth quantities of guar give the desired result, obviously satisfactory blinding action occurs with the coverage of only the more readily exposed clay surface.

Prior practice entailed the use of starch as the blinding agent. While results with starch are acceptable, they do not equal those obtained with

mannogalactan. Blinding agents are at best of a short-lived nature because of the greater attractive forces in play between the cationic collector and the montmorillonite. In the authors' opinion, the basic superiority of mannogalactan lies in the increased bonding strength which renders it less susceptible to displacement by the collector. In practice, one-quarter quantities of mannogalactan give equal flotation results and a marked improvement in circuit brine clarity. This latter point, as seen in Fig. 7, clearly illustrates the advantage of tailored reagents in closed circuit systems. The general refinery flow diagram in Fig. 8 shows the adaptation of the Krystal unit and the conditioning technique applied to mannogalactan.

In summary, the use of temperature control and tailored reagents combine to give the Duval Sulphur & Potash Co. a highly efficient process, unaffected by seasonal temperature variations.

Acknowledgments

The authors wish to acknowledge the generous assistance of O. A. Moe and W. A. Jordan of General Mills, Inc., in developing mannogalactan as a clay-binding agent. They also express their thanks to Hans Svanoe of the Struthers-Wells Corp. for his valuable consulting service in applying Krystal practice to potassium chloride. In addition, the classic works of the referenced authors were of immeasurable help in clarifying the role of clay minerals in flotation processes.

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Wet Cleaning at the Tralee Preparation Plant

by Percy Gillie

THE Tralee preparation plant, owned and operated by the Semet-Solvay division of Allied Chemical and Dye Corp., is located on the Virginian railway, near Mullens, Wyoming County, W. Va., and the mine, which is in the Winding Gulf district, produces coal exclusively from Pocahontas No. 3 seam. The property, comprising 4900 acres, is leased from the Pocahontas Land Corp. Prior to 1930 four separate mines were operated in this tract, some having been started about 1916.

Plans for the preparation plant were formulated soon after World War II. Construction began in the spring of 1948, operation early in 1950. The plant was designed to be operated with minimum labor. It was equipped for production of first quality graded sizes of coal for house heating and ⅜x0-in. slack suitable for high-standard metallurgical coke.

In the beginning, a thorough investigation was made of the property by means of core drilling, prospect openings, and sections from shallow mines on the property, as well as sections and analyses from mines in the immediate vicinity. After the extent of desirable coal had been established and the average seam section and nature of overlying and underlying strata had been determined, it was decided to install a system of mining which would load the full seam and would clean the product mechanically.

Pocahontas No. 3 seam is characterized by draw slate and bone and rock partings. It was not known what the washing difficulties and cleaning plant requirements would be for processing the raw product of full mechanical mining. Arrangements were made, therefore, through the courtesy of the property owner, to obtain a large sample from a section of the mine along the adjoining property line. The

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place selected was representative of natural conditions observed in faces of entries in old workings of abandoned mines on the Tralee lease. To simulate mechanical loading, since the adjoining mine was operated by hand loading, drill holes were charged with sufficient explosives to pull down draw rock, rock partings, bone, and coal together. Large pieces of draw slate and bone were then broken up with a sledge hammer. A test on this material provided data to be used in designing the cleaning plant.

The washing studies also indicated that full mechanical mining would produce a raw product containing not only a very large amount of high gravity material but also considerable material of intermediate gravity which would increase materially the difficulty of separation. Previous washing tests made on less difficult coals in both full scale and pilot plants, and investigations and sampling in the cleaning plants throughout the eastern coal fields, over a period of several years, indicated that it would be necessary to wet wash both the slack and the 6x⅜-in. coal if the desired cleaning results were to be obtained with a minimum loss of coal in the refuse. As a result of these studies, a Rockmaster roll crusher, a Chance cone, Deister concentrator tables, and Bird filters were selected for the task.

Table I. Variations in the Raw Product of Full Mechanical Mining

Draw Slate, 18 In.			Draw Slate, 0 In.		
Type of Coal	In.	Ash	Type of Coal	In.	Ash
Coal	10.5	3.47	Coal	6.5	4.72
Gray coal	1.5	24.71	Gray coal	2.0	9.55
Slate	5.5	69.64	Bone	4.0	57.56
Coal	2.0	10.41	Coal	6.0	8.27
Bone	4.0	45.44	Coal	16.0	2.52
Coal	3.0	7.48	Bone	2.0	21.96
Coal	18.5	4.06			
Bony coal	1.0	14.36			
Coal	9.0	2.98			
Bony coal	1.0	18.76			

The Tralee coal cleaning plant is the first in the Pocahontas field equipped to clean the entire mine product with a Chance cone and Deister concentrator tables. This plant is now processing a raw product from which approximately one ton of material is rejected for each ton of clean coal loaded in the railroad car. This large amount of refuse is rejected entirely by mechanical means, as there is no picking table in the plant.

During the first few months of operation, it was found that long slabs of draw slate, when less than 6 in. thick, would pass through the crusher and become fouled in the cone refuse gates. This was overcome by the addition of scalping screens to remove the larger pieces.

The coal seam varies from 32 to 60 in., depending on the amount of bone and middleman, and is overlaid with a draw rock varying from 0 to 18 in. Typical variations, shown in Table I, produce wide fluctuations in the amount of material which must be rejected by the cleaning plant.

The coal is fed from a 50-ton dump hopper at rate of 450 tons per hr to a 6x10-ft Ripl-Flo screen that removes the −6 in. material. The +6 in. material is crushed in a 30x72-in. Rockmaster crusher, recombined with the throughs, and transported by belt conveyor into the main tipple. This material is distributed by means of a drag conveyor over six open top hoppers which feed to six 6x16-ft Ripl-Flo screens by means of adjustable startgate feeders.

Fig. 1—View of the Deister floor in the Tralee plant.

These six screens are unique in that they make three products, namely, refuse, coarse coal, and slack. When the +6 in. mine product is run through the crusher the draw slate tends to break into slabs. These large slabs are screened out by the top deck and go directly to the refuse bin. The second product is 6x⅜-in. coal which is cleaned in the Chance plant, and the third product is −⅜ in. slack which is cleaned in the Deister plant. The 6x⅜-in. raw coal is rescreened over a low head screen before it is sluiced into the cone, the purpose being to remove all the fines created by breakage or poor screening. This reduces silt accumulation in the Chance system.

It will be noted from data in Table II that approximately 9 pct of the raw feed with an ash of 74 pct is rejected by the six Ripl-Flo screens with 44 pct of the product going to the Chance cone and the remainder of 47 pct going to the Deister plant, which is shown in Fig. 1.

The coal is cleaned in a 13-ft 6-in. cone with 60 P-2 sand. The washing gravity in the cone is mainly controlled by varying the amount of water recirculated and by the size of sand retained. The amount of water is regulated by valves on each of four lines. Each of these lines supplies water to a ring from which the water is introduced into the cone by nozzles equidistant around the periphery of the cone. The nozzles point down parallel to the side of the cone so that material is flushed by down currents as well as rising currents of sand and water.

Table II. Run of Mine Feed After Crushing

Product, In.	Wt, Pct	Ash, Pct
+6	8.6	74.77
6 x ⅜	43.7	45.43
⅜ x 0	47.7	14.60

Control by size of sand is effected in two ways, by purchasing specifications and by control of the sand classifier. Sand purchased is of 42 to 63 fineness, American Foundrymen's Association standards. This is the theoretical mesh of the screen with which the average size of a grain of the sand would correspond. The finer sands are more suitable for low gravities, and the coarse sands for high gravities. During operation with a given grade of sand, the average size of the sand kept in circulation in the cone can be varied if water velocity is changed in the classi-

fier column, so that more or less sand is dropped out of the bottom of the vessel. When the sand pump is slowed down, the relative amount of sand in the cone and in other parts of the system can be varied. Return of sand by the pump can be slowed down by injection of fresh water into the pump suction. The operating gravity may change several hundredths because of a build-up or decrease in water solids in the system. It is important to check this build-up when there is a large amount of material near the operating gravity. It has been found necessary to use plenty of sand to maintain the efficiency, sand losses having run as high as five lb per ton during wet seasons. These sand losses can be minimized by wet screening ahead of the cone and other devices, but such screens were not incorporated in the design of the Tralee plant.

When operating at 1.40 sp gr the sinks in the clean coal vary from 0 in the larger sizes to 2 pct in the pea size as shown in Table III.

Table III. Cone Products from Operation at 1.40 Sp Gr

Sp Gr	Wt, Pct	Ash, Pct	Accumulative Wt, Pct	Accumulative Ash, Pct
6 x 3½-In. Egg				
−1.35	58.7	5.01	58.7	5.01
1.35 to 1.40	41.3	8.10	100.0	6.29
+1.40	0			
3½ x 1¾-In. Stove				
−1.35	66.3	4.74	66.3	4.74
1.35 to 1.40	33.0	8.50	99.3	5.99
+1.40	0.7	14.41	100.0	6.05
1¾ x ¾-In. Furnace				
−1.35	70.7	4.63	70.7	4.63
1.35 to 1.40	28.3	8.52	99.0	5.74
+1.40	1.0	13.27	100.0	5.82
¾ x ⅜-In. Pea				
−1.35	77.2	4.25	77.2	4.25
1.35 to 1.40	20.8	8.24	98.0	5.10
+1.40	2.0	12.51	100.0	5.25

This cone is the open discharge type which means that the refuse falls directly from the cone onto a desanding and dewatering screen without the necessity of using a bucket elevator. When operating at 1.40, Table IV, the float in the refuse is 7/10 of 1 pct and the ash content of the refuse is 65.2 pct.

Table IV. Cone Refuse Float and Sink Analysis 4-Hr Sample During Operation at 1.40 Sp Gr

Sp Gr	Wt, Pct	Ash, Pct	Accumulative Wt, Pct	Accumulative Ash, Pct
−1.35	0.1	5.15	0.1	5.15
1.35 to 1.40	0.6	11.50	0.7	10.60
1.40 to 1.45	2.2	15.94	2.9	14.65
1.45 to 1.50	5.0	20.50	7.9	18.35
1.50 to 1.60	6.3	26.50	14.2	21.96
1.60 to 1.70	5.1	37.70	19.3	26.12
+1.70	80.7	74.55	100.0	65.20
Total	100.0	65.20		

The clean coal which floats in the sand and water mixture is discharged onto a Parrish-type shaking screen, the first section of which is used entirely for dewatering and desanding. The second section is used to size the coal into four grades: +3½ in. egg, 3½x1¾-in. stove, 1¾x¾-in. furnace, and ¾x⅜-in. pea. These grades are loaded by means of drag-type loading booms equipped with oil sprays, oil metering devices, and degradation screens. The degradation is conveyed back and in turn is rescreened over a double-deck vibrating screen which dewaters and sizes the pea coal. This screen is equipped on the bottom deck with a ½-mm screen cloth. The plus material goes to the slack car and the minus material, which is mostly sand and silt, flows to the sand sump. The screening plant is equipped with a mixing conveyor so that any of the sizes may be blended together, loaded into the slack car, or conveyed to the house coal bin.

The ⅜x0-in. slack which is screened out by the six Ripl-Flo raw coal screens is elevated by means of a drag conveyor to the top of a 100-ton storage and surge bin at a maximum rate of 250 tons per hr. One of the most important functions of this bin is to provide sufficient storage so that the table plant can be operated continuously. The coal fed from this bin is regulated by a variable speed rotary feeder which discharges it into a flight conveyor that elevates the coal to what is called a splitter box. At this point, the dry slack falls into the rising current of water which is used to wet the coal and convey it to the table distributors. The quantity of water used in the splitter box amounts to about 1400 gal per min. The purpose of the distributor is to divide the feed equally and without segregation to each of the tables.

The coal and water are fed to the concentrating tables at the rate of 10 tons of coal per table per hr. To clean the quantity of fines, it was necessary to have 20 tables, which were installed on two floors. Feed requirements are shown in Table V.

Table V. Screen Analysis of Raw Slack to Concentrating Tables

Size, Mesh	Wt	Ash
+⅜	3.1	49.72
−⅜+¼	12.3	19.07
−¼+8	24.0	13.73
−8+16	19.8	12.24
−16+30	15.5	11.29
−30+50	10.8	10.24
−50+100	6.3	11.56
−100+200	3.4	11.12
−200	4.8	21.53
Total	100.0	

The tables are the diagonal deck type. Approximately equal weights of coal and water are fed at one corner of the table. Additional dressing water is added at two points along the back of the table to wash the coal over the riffles, which are diagonal to flow of coal. A suitable conveying motion is imparted to the tables by a 3-hp motor. This motion is parallel to the riffles, shaking the material away from the coal overflow lip at a 45° angle toward the refuse side of the table.

Control of the separation on tables is effected by the following adjustments in order of their importance: 1—end elevation of table, 2—amount of dressing water added, 3—side tilt of table, 4—amount of water added with feed, and 5—length of stroke and number per minute.

Even after seeking the optimum combination of these adjustments it was found that, although the overall ash was satisfactory, there was still an objectionable quantity of intermediate gravity material reporting to the clean coal. It will be seen in Fig. 2 that this high ash material is concentrated in the middling zone of the table. When this high ash material is diverted to refuse, the fine coal also goes to refuse. Coarse bone and fine coal tend to come off the table at the same place, as is usual on tables with unclassified feeds.

It was found that it was very simple to correct this defect by installing a fence along the coal edge

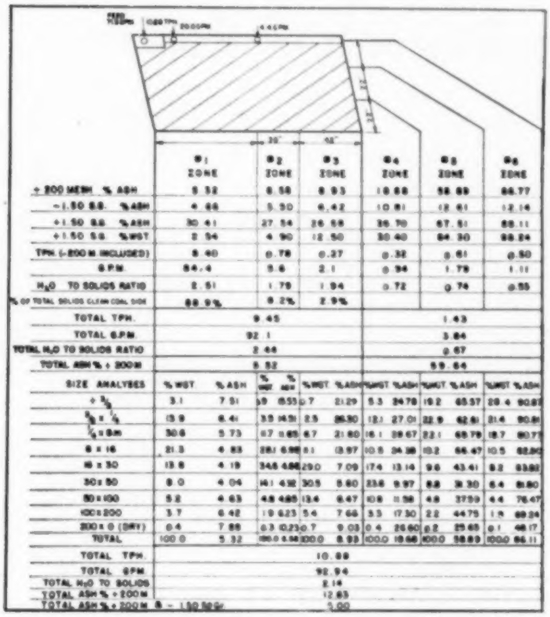

Fig. 2—Zone test on tables (5).

of the table. The fence consists of a 42x4-in. piece of ¼x3-in. Tyrod screen cloth cut and mounted along the No. 3 zone (Fig. 2) edge of the table with the slots vertical. It works because the conveying action moves large particles away from the fence so that it does not become obstructed. Table VI shows an ash and screen analysis of the table product after installation of the fence.

The clean coal and water from the tables is conveyed by sluices to a 5-way distributor which in turn is used to feed the five 54x70 solid bowl centrifugal dryers manufactured by the Bird Machine Co. The ratio of the water to the coal in the feed is generally 2 to 1 by weight. The Bird centrifugals dewater the coal from a feed moisture of approximately 67 pct to a discharge surface moisture of 6 to 8 pct. The coal from the Birds is discharged onto a flight conveyor which conveys and elevates it to a mixing conveyor or cross belt for loading into railroad cars.

Table VI. Clean Coal* Screen Analysis after Installation of ¼-in. Fence

			Accumulative	
Size, Mesh	Wt, Pct	Ash, Pct	Wt, Pct	Ash, Pct
+ ⅜	2.2	6.47	2.2	6.47
− ⅜ + ¼	11.4	5.47	13.6	5.63
− ¼ + 8	24.8	5.16	38.4	5.33
−8 + 16	20.9	4.20	59.3	4.93
−30 + 50	10.0	3.85	83.5	4.57
−50 + 100	7.2	4.65	90.7	4.57
−100 + 200	6.4	6.23	97.1	4.68
−200	2.9	7.51	100.0	4.77

* Washed on 200-mesh sieve before analysis.
Wet −200 mesh discarded.

Also of interest in the fine coal cleaning plant is the installation of a cyclone in the dressing water lines going to the various tables. This removes all the tramp material including the coarse coal from these lines so that the valves do not become clogged. Before installation of this cyclone, constant knocking on the valves was necessary to keep them unstopped.

The Bird machines as originally furnished operated at a speed of 640 rpm. Tests made at another plant indicated that they could be operated at a slower speed. The Birds at Tralee are now operated at a speed of 480 rpm. This reduces the horsepower requirements of these machines 30 pct and also decreases the amount of breakage and lowers the moisture in the discharge cake. Results accomplished by these changes are shown in Table VII.

The screws in the Bird machine have been redesigned so that part of the screw is used as a centrifugal pump, pumping water out at a high velocity into the partially dewatered coal being conveyed up the so-called beach of the machine. The purpose of this high velocity stream of water is to remove the clay or deslime the slack. The clay and slime retain several times their weight in moisture, so that this desliming has actually produced two results: first, a lowering of the moisture content of the coal, and second, decreasing of the ash of the coal coming from the machine as shown in Table VII.

Refuse from the various tables is conveyed by sluices to a rectangular sludge tank from which the material is removed by a drag conveyor. The material as removed contains approximately 20 pct moisture. The entire amount of refuse from the mine, both mine rock and washer reject, is conveyed by means of a belt conveyor to a 240-ton aerial tramway bin. It is loaded from the bottom of this bin into a continuous aerial tramway which conveys and elevates it to a transfer bin at the top of a mountain. It is finally disposed of by a 2-bucket jig-back disposal tramway. The disposal area is sufficient to hold approximately 20 million tons of refuse.

Table VII. Tests on Bird Machines Operating at 640 rpm vs 480 rpm

Item	Bird No. 1		Bird No. 2	
Bird cake, pct total moisture	17.00		10.60	
Effluents, pct solids	5.55		8.45	
Wash, gpm	0		175 Bird effluent	
Pool, in.	1¼		1¼	
Speed, rpm	640		480	
Foxboro reading	310		250	
Amperes, input	200		135	
Bird Cake Screen Analyses, Wet Washed on 200-Mesh Sieve				
Screen Size, Mesh	**Cake, Wt Pct**		**Cake, Wt Pct**	
+ ⅜	0.2		0.4	
− ⅜ + ¼	3.7		5.4	
− ¼ + 8	17.4		26.6	
−8 + 16	17.1		22.4	
−16 + 30	15.1		13.9	
−30 + 50	12.3		10.0	
−50 + 100	10.4		7.6	
−100 + 200	7.4		3.8	
−200	16.4		9.9	
Total	100.0		100.0	
Effluent Screen Analyses				
Screen Size, Mesh	**Wt, Pct**	**Ash, Pct**	**Wt, Pct**	**Ash, Pct**
+ 100	0.6	10.89	20.4	3.10
−100 + 200	1.6	4.93	9.5	3.95
−200 + 325	22.3	3.84	20.8	4.46
−325	75.5	37.99	49.3	36.68
Total	100.0	29.68	100.0	20.24

A dumper, cone operator, table operator, pump attendant, and clean-up man are required to operate the tipple and cleaning plant.

No greasers are needed, as all the machinery is lubricated by centralized automatic facilities. There are three men to clean and handle the railroad cars to and from the tipple and one operator for the aerial tramway.

At the present time information received from consumers indicates that an acceptable product is being produced with a minimum of operating labor from a coal seam with exceptionally difficult washing characteristics.

The Status of Testing Strength of Rocks

by Rudolph G. Wuerker

The progress made in testing the strength of rocks and minerals as they are encountered in mine operation is reviewed. An attempt is made to correlate these physical measurements with abrasive hardness, grindability, and behavior in comminution on one hand and fracture of rocks in pillars and roof control on the other.

THIS paper reviews the progress made in testing the strength of rocks, ores, coal, salts, and other minerals as they are encountered in mine operations. It attempts to correlate the results of these physical measurements with technological properties more useful to the mining engineer: abrasive hardness, grindability, and behavior in comminution on one hand, and roof control, fracture of rocks in pillars, and mining methods with controlled caving on the other. In the following pages, the materials discussed will be referred to as *rocks*.

Basic to rock mechanics and comminution are the problems of strength, elastic behavior, and failure, common to all brittle materials. A distinction will be drawn as to theoretical and applied research, and discussion of the progress made in each field will include test data obtained by the U.S. Bureau of Standards,[1-4] the U.S. Bureau of Mines,[5-7] the Iowa Engineering Experiment Station,[8,9] the Committee on Geophysical Research at Harvard University,[10] Basic Industries Research of the Allis-Chalmers Manufacturing Co.,[11,12] by Philipps,[13] and by Mueller,[14] to name only a few.

With refinements of testing methods and increased standardization, more useful and more comparable results have been achieved. This is especially important in testing a material like rock, as the inherent heterogeneity demands careful and exacting procedures. New measuring procedures that appear to supersede well known standard methods have contributed to faster and less costly testing yet have introduced new concepts, with implications as to comparability of results which must be watched. Reference is made to the sonic method for determining elastic properties,[5] to be discussed in detail below.

Basic Investigations

Historically, all work in the field has started with the simplest determinations such as those for crushing strength, abrasive hardness, and grindability. These serve the limited objectives in the researcher's field of specialization: building construction, road ballast, roof control in mines, comminution, and seismic prospecting. Occasionally, fundamental properties like the modulus of elasticity E and Poisson's ratio ν have been determined with the idea that they might have some bearing on the technological properties of the material under investigation. But it was not until the work of Philipps,[13] of Harvard University,[10] and of the U.S. Bureau of Mines[6,7] that sufficient basic data were collected to allow researchers to go beyond the technological test and find the fundamental laws behind the behavior of rocks in mine and mill operations.

The properties to be looked for are those that describe the elastic behavior of any material, the modulus of elasticity E and Poisson's ratio ν being the ones determinable with least difficulties. Only two such properties are required to compute any other property such as the shear modulus, the modulus of rigidity, and the bulk modulus, all of which are related to each other according to well known equations of the theory of elasticity.[10] In spite of their heterogeneous character, all rocks tested have possessed elastic properties. This does not mean that rocks of the same type always have the same modulus of elasticity, which varies exactly as the crushing strength or any other physical property of a rock can spread over a wide range. This has been explained by imperfections of the material always found in rocks, but to some extent this scattering of data is caused by inaccuracies inherent in the testing methods.

Modulus of Resilience, a Criterion of Failure

Increased availability of E values should allow us to test the validity of the quantity of strain energy theory which has been used in the solution of roof control problems by Philipps[13] and by Holland.[15] Recently Bond and Wang[12] have applied this theory to explain the failure of an elastic material in comminution. Actually it is a very old theory, proposed as far back as 1885 by Beltrami.[16] By its assumption the condition of yielding is determined by the term

$M_r = \frac{S^2}{2E}$ x volume. Here M_r is the modulus of resilience, and its dimension is inch-pounds per cubic inch, that is, work per unit volume. Its numerical value is equal to the area under the stress-strain diagram. In the foregoing equation S is the yield stress (in psi) in tension or compression, whatever the case may be. E, the modulus of elasticity, is in psi.

The great appeal of Beltrami's concept of stored energy lies in the fact that the two properties which seem to influence failure most, strength and elasticity, occur in the formula for the modulus of resilience. As an illustration of this, the moduli of resilience in compression of some typical materials tested by the U.S. Bureau of Mines[6] have been plotted in Fig. 1. The sample of concrete of conventional mix is shown only for the sake of comparison. Its determination was made in the Department of Mining and Metallurgical Engineering, University of Illinois. The values of the moduli of resilience of the various specimens in the plot are:

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Discussion on this paper, TP 3556A, may be sent (2 copies) to AIME before Jan. 31, 1954. Manuscript, Feb. 18, 1952. New York Meeting, February 1952.

Rock			In.-Lb Per Cu In.
Jaspilite	(8.4)	=	448.0
Hematite ore	(8.3)	=	134.0
Amphibolite	(17.2A)	=	124.5
Marble	(1.1)	=	66.3
Concrete		=	5.0
Sandstone	(1.4)	=	62.5

The concept of strain-energy, expressed by M_r and represented graphically by the area under the stress-strain diagram, shows clearly the dependence of our rocks on the two variables, strength and elasticity. Although in the plot the marble (1.1) and the sandstone (1.4) have about the same modulus of resilience, it is evident from their stress-strain diagrams, shown in Fig. 1, that the former sustains a much higher load and a smaller deformation, and that the latter sustains a smaller load but offers a much greater yield. The overall energy, nevertheless, to crush 1 cu in. of either material is, theoretically, about the same. Whether or not this approach will lead to better understanding of the problems of comminution and rock mechanics will depend upon further data. In most cases, insufficient elastic values are given in published data on crushing and grinding.

Besides the need for a greater number of E values, there is also a need for agreement on the methods of their determination and on interpretation of test data. For only in exceptional cases in the static determination of the modulus of elasticity of rocks are straight-line relations between stress and strain obtained.

In the ASTM standard test for determining compressive strength of rocks (C 170-41 T), modified somewhat by the U.S. Bureau of Mines,[5] three types of stress-strain diagrams are usually obtained: straight line, S-shaped, and steady-curving.

Fig. 2, which is taken from Kessler's[1] tests, shows repetition tests with six specimens of limestone. The parallelism of the curves upon repeated loading and unloading is indeed remarkable. While it is typical for dense, homogeneous rock, there are not such straight and reproducible lines for coarser-grained and less consolidated rock, especially upon repeated loading. But the coarser rock always shows an elastic phase, as can be seen from the stress-strain diagram of coal loaded to fracture, Fig. 3, which is typical for an S-shaped curve. This type of stress-strain curve is the most common, and has been obtained from rocks, concrete, ore, salt, wood, and similar more or less coarse-grained and brittle materials. Three different phases can be distinguished here, 1—a slope from the point of origin to 2—a straight line portion, and 3—a bending away from the straight line toward the point of failure. Phases 1 and 3 are often more or less pronounced, although sometimes they are completely missing.

Phase 1, curving up and showing increasing values of the modulus of elasticity with increasing stress, is probably due to the increasing compacting of the specimen and to an adjustment of the specimen in the fixtures. This phenomenon has been given undue attention by many investigators, especially the geophysicists, where rocks and similar materials were not loaded to failure. This is understandable when repetition tests are made, but it is not a recommended procedure for obtaining full knowledge of the way rocks behave up to, and at,

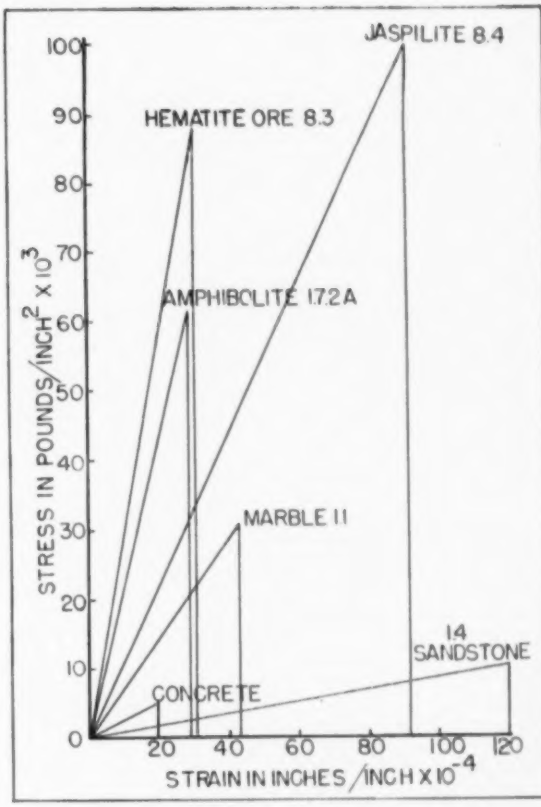

Fig. 1—Moduli of resilience of some typical rocks tested by the U. S. Bureau of Mines. The dolomitic marble is found at Cockeysville, Md. The sandstone, which is porous and weakly cemented, is from Amherst, Ohio. The intricately banded, medium-to-coarse-grained hematite is mined at the Soudan iron mine, St. Louis County, Minn., by the Oliver Mining Co. The jaspilite, comprised of alternating bands of chalcedony, cherty hematite, hematite, and magnetite is also from this mine. The amphibolite, two-thirds of which is composed of actinolite, also contains quartz, feldspar, epidote, and sphene. The samples of amphibolite were taken from the Nundydroog Gold mine, Nundydroog Mines, Ltd., at Oorgaum, Mysore State, South India.

failure. If a test is run until fracture, there is always a portion in the stress-strain diagram, in most cases having the steepest slope, through which a straight line can be drawn. This might be called the *apparent* modulus of elasticity, analogous to the *apparent* specific gravity in the ASTM tests, although this term is not in common use.

Another stress-strain curve of a brittle material of the steadily curving type, phase 3, is given in Fig. 4. It is taken from a concrete compression test, and like Fig. 3 it shows a steady curving of the line toward the point of fracture. As it is difficult in this case to find a straight-line portion, or even the *apparent* modulus, concrete manufacturers, who have the most experience with such a curve, work with the following moduli of elasticity that can be represented by a straight line:

1—The initial tangent modulus. This is the line drawn as a tangent to the stress-strain curve through the point of origin, *a* in Fig. 4,

2—the tangent modulus for a given stress, *b* in Fig. 4, and

3—the secant modulus at a given stress, usually the proportional limit stress, if this point can be

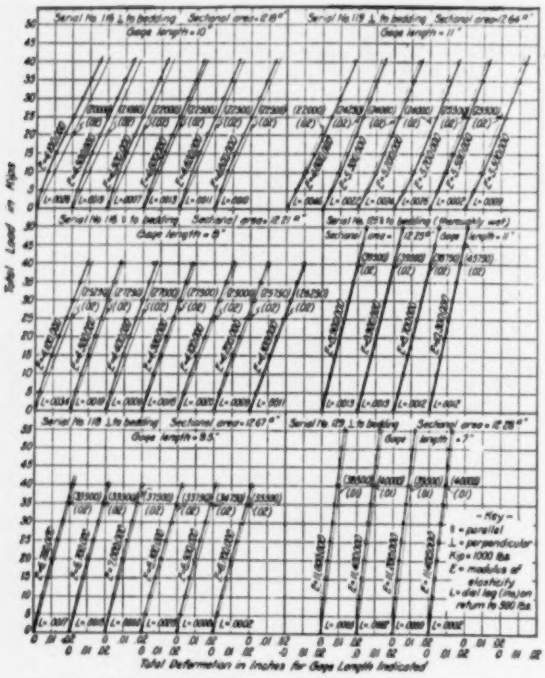

Fig. 2—Elastic deformation curves obtained for specimens of limestone, showing repetition tests. (After D. W. Kessler and W. H. Sligh, U. S. Bur. of Standards TP 349).

found on the curve, or at any other assumed stress, c in Fig. 4. This secant modulus of elasticity is the one most commonly used in design. As it is always less than the actual modulus of elasticity and less than the tangent moduli, it is also the safer one.

If an attempt is made to draw the secant modulus to a curve as in Fig. 3, which is a more common type of curve than the one in Fig. 4, the difficulty arises as to how to fit in a secant line which should go through the point of origin. This is why the *apparent* modulus of elasticity has been suggested.

Until the advent of the sonic testing method for determination of elastic properties, only static tests were used for measuring of E and ν. The modulus of elasticity thus found would be any of the three aforementioned tangent moduli for a given stress (a and b in Fig. 4), or any of the secant moduli (c) that could possibly be fitted into the stress-strain diagram, or the *apparent* modulus of elasticity. E determined by the sonic method is always the initial tangent modulus (a in Fig. 4) and is always a higher value than the moduli gained from static testing. There is obviously the danger of an inaccuracy in the indiscriminate use of existing testing methods, a practice which should be avoided if the experimenter wishes to arrive at definite, indisputable physical data.

E of brittle materials is not a constant property but changes with the speed of loading. Philipps, see Fig. 5, has published stress-strain diagrams of shales tested at various speeds. E from a test that reached 12,000 psi in 10 min was 25 pct less than that at immediate deformation. The rate of loading of 100 psi per sec, as specified in ASTM and U.S. Bureau of Mines procedures, would be represented by the 2-min curve in Fig. 5 which gives a value of about 20 pct less than that obtained by a rapidly applied load, as in the sonic test. Similar discrepancies can be expected with indiscriminately used values obtained by different methods or by any of the three possible E's from the static method.

To summarize this point, a decision by a standardizing agency on this question would greatly contribute to usefulness and reproducibility of future data. Such an agreement would be as helpful as the specification of a speed of loading 100 psi per sec in the standard compression test. Until then, elastic properties of rocks determined in the past by various methods should be used judiciously.

Applied Investigations: Relation Between Basic and Technological Properties

The fundamental physical properties discussed in the foregoing will in all probability be used only in the study of the problem of fracture of rocks. Their determination requires testing equipment that will be found only in universities and testing laboratories. Another disadvantage is that most tests (except the sonic) are destructive and require a greater number of specimens, leading to increased costs. Furthermore, a statistical average of a great number of tests has to be taken, as rocks do not possess definite properties. This is explicitly specified in the U.S. Bureau of Mines standardized tests.[8] Here, in the case of compressive strength, it is recommended that the average of 10 determinations be used.

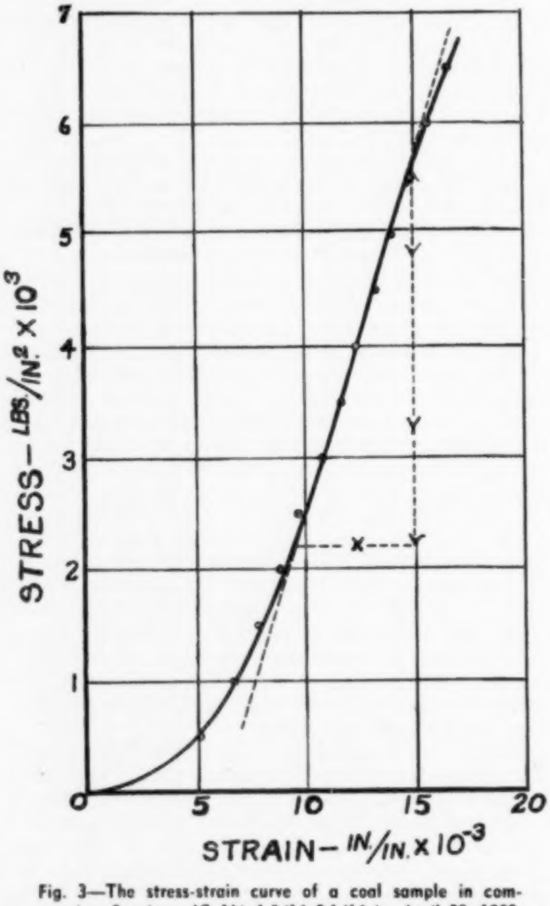

Fig. 3—The stress-strain curve of a coal sample in compression. Specimen IC_0 1½x1 9/16x2 1/16 in. April 29, 1952. Olsen machine. Modulus of elasticity $= \frac{Y}{X} = \frac{3400}{0.0055} =$ 618,000 psi.

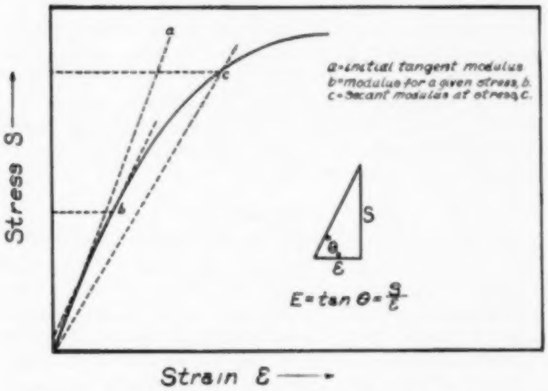

Fig. 4—The stress-strain curve of a brittle material. Various moduli of elasticity.

The trend will be necessarily toward nondestructive and less expensive correlative tests, just as in metal shop work elastic properties, strength, and workability of a piece can be determined by such a simple test as, for example, the Rockwell hardness test.

Correlation of Strength Properties with Density and Absorption

Most of the researchers quoted here have given correlations of elastic and strength properties of rocks with easily determined quantities like density, absorption percentage, or hardness. Correlation with density would be an ideal and most simple procedure, but in all the literature reviewed only one successful case has come to the writer's attention. Kessler-Sligh[1] in their investigation of the physical properties of limestones arrived at a straight-line expression for the ratio of compressive strength to density which is very impressive but which could not be found with any other rock. Limestone apparently is quite free of cavities, bedding planes, and other imperfections, and will give a fair straight-line expression. It might be possible that single rock types of a given mine or a given locality may give similar simple relations. But applied to groups of rocks, like the 97 rocks tested by Griffith, comprising igneous, metamorphic, and sedimentary types, or applied to the 100 or more rock varieties from operating mines or mineral-investigation projects tested by the U.S. Bureau of Mines, this procedure is a failure.

Griffith[8] has chosen a property closely related to density, namely, absorption. His argument is that "the physical behavior of rocks is conditioned much more by their relative degrees of molecular dispersion or states of aggregation than by their chemical constitution." His argument is very plausible in the extreme case of diatomaceous silica and chert. He says, "Both are modes of silica, but the one absorbed 154.6 percent of water by weight and supported 477 psi., while the other absorbed hardly any water and carried 86,300 psi." A similar test made at the Department of Mining and Metallurgical Engineering at the University of Illinois with coal and coke gave for coal 4000 psi compressive strength and 16 pct absorption and for coke 780 psi supported unit load at 59.8 pct absorption (averages of three tests). While for such extreme cases Griffith's argument might be acceptable, there is in his plot of compressive strength vs absorption a crowding of values in the absorption range from 0 to 2 pct, and the parameters given by him become meaningless here. The majority of his measured values fall in this range. Salt rock, coal, and many sedimentary rocks will not be amenable to the absorption test at all, as they disintegrate during the boiling period required in this test.

Correlation of Strength Properties with Rebound Hardness

Better results are gained by the correlation of compressive strength with rebound hardness as determined with the Shore scleroscope. This too has been suggested by Griffith, and the value

$$S_c = 300\,h\left(1 \pm \frac{1}{10}\right)$$

has been given by him for the compressive strength (S_c) as a function of scleroscope hardness h for averages of the data rocks tested at the Iowa State College Engineering Experiment Station.[8]

This correlation applied by the author to the group of more than 100 rocks studied by the U.S. Bureau of Mines gave better results than any other attempt. As can be seen from the curves on Fig. 6, the relation of compressive strength to scleroscope hardness can be fairly described by $S_c = 400\ h_{scler.}$ as average value. Griffith's formula $S_c = 300\ h_{scler.}$ forms, with the rocks of the U.S. Bureau of Mines test series, the lower limiting value and $S_c = 500\ h_{scler.}$ the upper parameter, although the few extremely strong rocks found by the U.S. Bureau of Mines lie even beyond this formula. Some of the high strength values are not shown at all, as the ordinate does not extend beyond 50,000 psi. The correlation should be considered as a first attempt. Possibly a parabola would fit the plotted values better than a straight line, and more definite values could perhaps be obtained by correlating the properties of single rocks or rock types, as in the case of the limestone shown in Fig. 2, instead of a group composed of 100 and more different rocks.

The gratifying results with this correlation attempt encouraged the author to test relations of scleroscope hardness with other technological properties. In Fig. 7 scleroscope hardness is plotted against abrasion hardness, as determined by the modified Dorry abrasive hardness test.[9] The values are again from the U.S. Bureau of Mines test series[9] of more than 100 different rocks of all sorts and of some iron ores. In spite of their diversified origin, composition, and texture, parabolas could be found

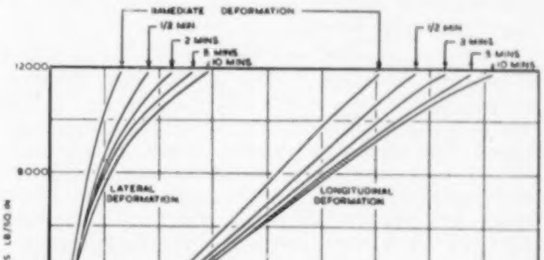

Fig. 5—Effect of time of loading on stress-strain diagram, compression. (After D. W. Philipps, *Colliery Engineering*, August 1948, p. 281.)

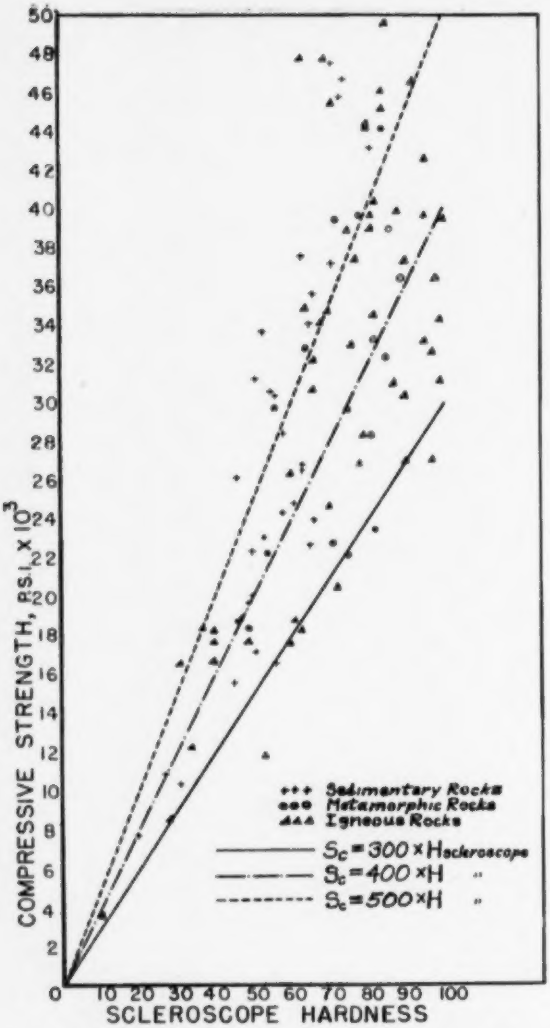

Fig. 6—Scleroscope hardness vs compressive strength of rocks tested by the U. S. Bureau of Mines. (Data from U. S. Bur. Mines R. I. 4459.)

to describe the parameters or an average value for this relation. Here again it is felt that a more definite correlation might be obtainable if rocks of only the same type were tested and correlated, instead of groups of rocks.

There are no more test series available in which scleroscope hardness values have been obtained, so that no further proofs for the validity of the relations established in the foregoing can be obtained. The scleroscope hardness test is fast, inexpensive, and non-destructive. If its general applicability could be established, a way would be found to get strength or other physical data without having need for the apparatus of a testing laboratory. Testing, by means of correlation tests, should thus be possible at mine laboratories, whenever problems of roof control, drill speed progress, and the like arise.

Hardness Correlated to Complex Properties Used in Comminution

This interesting possibility of correlating hardness with those properties of rock that are extremely difficult to determine, such as surface-energy relationships in comminution, has been intimated by Schellinger[17] and by Kwong-Adams-Johnson-Piret.[18] Although only a few rocks were tested by these authors, certain agreement with Moh's hardness was noted. Schellinger states that if a different hardness number than the non-linear Moh's scale had been used, a straight-line relation might have been possible, see Fig. 8.

Conclusions

1—Experimental work has proved the applicability of the theory of elasticity and of the standard methods of testing materials to rocks, ores, and other minerals with which mine and mill operators have to deal. This statement holds unrestricted for igneous and metamorphic rocks and so-called *strong* ores. Sedimentary rocks are sometimes not very consistent in their elastic behavior and must be evaluated with special statistic procedures. They are in many respects similar to common engineering materials like cement or wood. The geophysicist in seismic work likewise utilizes the elastic properties of sedimentary rocks in computing the travel speed of a wave, and the petroleum engineer, too, in reservoir engineering, also works with physical properties that are indeterminate. In neither field of activity has the success of the methods been influenced. In soil mechanics much less consolidated material than the sedimentary rocks of mining areas has been evaluated as to its elastic and plastic properties and utilized successfully in design.

2—Knowledge of strength properties of rocks as used in fundamental studies would be increased by more exact testing and by agreement on procedures. More definite data could without doubt be obtained if all pertinent tests were made with selected rocks that are typical for their strength properties. Still better, man-made rocks fabricated under controlled condi-

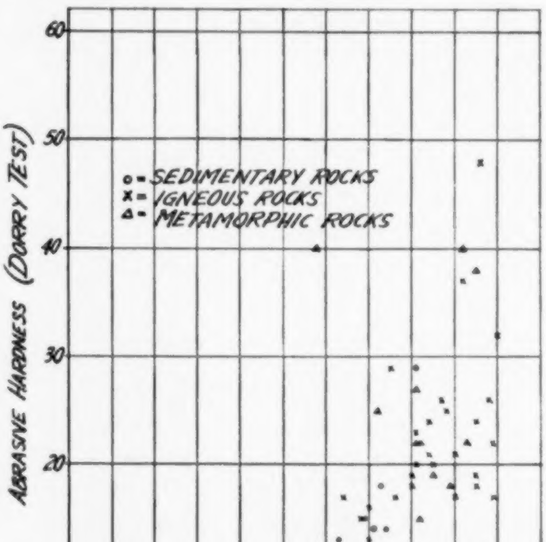

Fig. 7—Scleroscope hardness vs abrasion hardness of rocks tested by the U. S. Bureau of Mines.

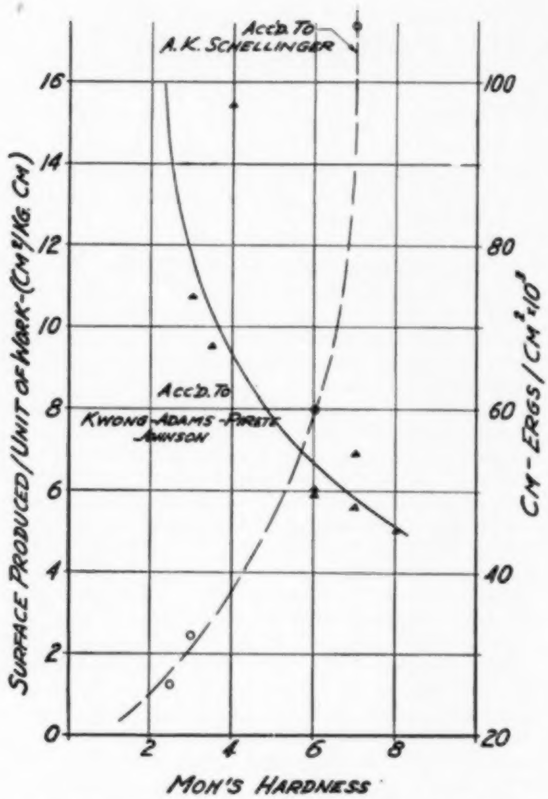

Fig. 8—Moh's hardness related to comminution quantities.

tions could be employed for making the necessary number of repetition tests. For low strength tests neat cement or cement mortar could be used. Igneous rocks could be similated by bricks ranging from conventional clay bricks up to silica fire-bricks. Thus the inherent heterogeneity of natural rocks and the resultant diverse strength properties could be compensated for and the number of variables reduced.

3—Rocks of importance only to a special mine or to a localized mining district preferably should be tested at the site of operation. Correlations with technological properties or with the costs of various mining processes are of interest only to the particular case. However, methods and testing equipment should be the same as those used in the search for basic physical properties.

Harley[19] in 1926 proposed a system of ground classification for estimating the collective strength of rock as it would affect stoping operations, the drilling rate for setting contract work, and other operational data. Although some suggested testing methods reflect the status of testing of a generation ago, his paper states, though only qualitatively, the same facts that have been proved quantitatively by the later more exacting test which served as basis for this review.

Acknowledgments

This work is part of a comprehensive program of investigating strength properties of rocks undertaken by the Department of Theoretical and Applied Mechanics at the University of Illinois. The wholehearted support given the project by Professor H. L. Walker, Chairman of the Department, is herewith gratefully acknowledged. The tests performed at the University were made in the Department of Applied Mechanics. Its staff extended all possible assistance. Samples for the tests at the University of Illinois were supplied by the Murdock Mine of the Bell and Zoller Coal and Mining Co., Murdock, Ill. Most of the actual testing, computing, plotting, and preparation of data for the manuscript was done over a period of almost two years by Messrs. J. R. Miller, N. Szabo, A. Risi, and J. W. Snarr, all former students of the Department of Mining and Metallurgical Engineering at the University of Illinois.

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The Mineralogy of Blast Furnace Sinter

by Hobart M. Kraner

THE mineralogy of blast furnace sinter is of interest because its mineral content is one of the important factors contributing to its character. There are so many other factors affecting the properties of the sinter, however, that it is well to mention them here. The proportion and character of the raw materials, that is, raw ores, concentrates, returns, and fuel, as well as the mixing and the water content, all have a marked effect on the physical properties of the product and the degree to which sintering action can be carried on. The process of sintering is a relatively fast operation. In as much as appreciable time is required to carry on processes of fusion in such masses of low thermal conductivity, large lumps of hematite ore frequently remain unfused and partly unchanged in state of oxidation in the sintering process. The kind, the grain size, and the amount of fuel used affect both the completeness of the fluxing reaction and the prevailing atmosphere. The rate of reduction in laboratory tests is not only dependent upon the state of oxidation of the sinter but also upon the sizing and porosity.

Atmosphere and temperature affect the state of oxidation of the iron oxide, and the atmosphere alone may determine the ferrous minerals that finally develop. The rate and extent of cooling, the type of coolant, the subsequent handling, and screening all have serious effects upon the type of sinter that eventually enters blast furnace bins.

The degree to which actual fusion or fluxing takes place in the sintering operation has a marked effect upon density. A sinter which has been extensively fused by high content of fuel in the batch will no doubt have a higher weight on the bulk basis than one which had a lower fuel content. As high temperatures are required to do this job, the iron oxide under these conditions will be largely magnetite. Sintering at low temperatures to produce larger proportions of hematite means a decrease in the amount of liquid formed and a much more sensitive bonding process. In this case the liquid must be distributed more uniformly and thereby used more efficiently than would be the case where higher temperatures were permitted to prevail more or less indiscriminately.

Where coarse ore particles are used in a sinter mix it is not expected that any particles coarser than ¼-in. can be fused and incorporated in the system to such an extent that the gangue contained within these lumps will have been converted or fused by the sintering process. It is for this reason that coarse ore, returns, or both, in a sinter usually result in a sinter which breaks easily and at the same time may contain some of the original minerals of the lump, such as quartz and hematite.

In examination of sinters at Bethlehem Steel Co. minerals such as quartz and corundum have been found, none of which are considered normal associates of wustite or magnetite. Some degree of heterogeneity or lack of equilibrium is not unusual in the sintering process.

The differences in specific gravity between hematite and magnetite might be ample reason for poor strength in a not very well sintered mass containing coarse particles of ore or returns. The shrinkage taking place in a lump of hematite in its conversion to magnetite by temperature and/or atmosphere is appreciable.

Sintering of ores as it is carried out is crude chemistry, for the grain size is relatively coarse, the application of heat is certainly not uniform, and the time factor is inadequate for other than partial completion of reactions. Coarse lumps of coke or coal cause local heating around these centers, and fuel which is too fine may result in such slow burning that sufficiently high temperatures are not always obtained. High temperatures are essential to the work required. The Swedish practice of sintering is established on the basis of producing an easily reducible product high in hematite. This is achieved through uniformity of grain size in the sinter mix and close control of the temperature through careful regulation of fuel and sintering rates. This produces a sinter which is very tough in character and which has a high degree of porosity. Although the hematite content is not produced upon cooling by drawing air through the mass, there would be greater possibility of accomplishing this reaction with this type of sinter than is the case in American practice. In the latter, the temperatures are so high that temperature alone converts most of the mass to magnetite. The grains are so coarse in the final product that together with the fluxed condition it would be difficult to reoxidize them to hematite upon cooling.

An examination of the iron-oxygen diagram[1] shows that hematite does not exist above 2651°F. It also shows that there is no liquid in the pure magnetite-hematite system until 2881°F is reached. On the other hand, in the system magnetite-wustite liquids exist at considerably lower temperatures than this. It will be seen, therefore, considering only the iron oxides, that the bonding action obtained in America in sinters comes about through considerable temperature and/or reducing conditions that produce compositions containing even less oxygen than is contained in magnetite or than results from the fusion of silicates. The bonding obtained from the iron oxides is encouraged by the reducing conditions that prevail in the vicinity of the fuel particles in a mass of this sort, where temperatures are above 2600°F.

As magnetite and wustite are opaque, they do not lend themselves to petrographic study by transmitted polarized light. The silicates found in sinter and the glass that has not crystallized transmit light and can be studied by these methods in which indices of refraction and other optical properties of anisotropic crystals lead to their definite identification. The index of refraction is the only property that can be measured in glass under the microscope, and this is a clue to its probable approximate composition.

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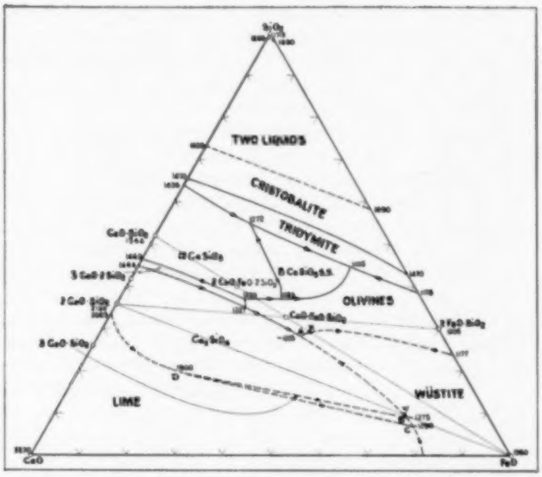

Fig. 1—Equilibrium diagram of the system $CaO\text{-}FeO\text{-}SiO_2$. (After Bowen, Schairer, and Posnjak, *American Journal of Science*, September 1933, with additions by Muan and Osborn.)

Use of reflected light from the polished surface is a very helpful method of studying the structure and composition of the wustite, magnetite, and hematite. While it does not yield determinative data on the anisotropic phases or the glass, each can be identified in their broad categories as silicates and glasses and are thus distinguished from the iron oxide phase. It is possible, therefore, to study the relative proportions, distribution, and occurrence of magnetite, hematite, anisotropic silicates, and glasses in sinter structures by this means.

A petrographic examination of sinters shows the evidence of recrystallization of magnetite. Although magnetite is opaque, when it crystallizes the crystals can be seen extending into the glassy matrix. This does not necessarily mean that the temperature was sufficiently high to melt magnetite, but it does mean that magnetite had crystallized from a liquid phase, which was present during the sintering operation. Such liquids naturally include almost all the minor constituents shown in the chemical analysis of the sinter and a reasonable part of the iron oxides as well. The minor constituents, therefore, have an important bearing on the mineral constitution of the sinter. The rate of cooling and the proportion of silica, or its proportion relative to the *bases* present, has a marked effect upon whether crystallization takes place or solution remains as an uncrystallized bond—a glass. Although it is known that such siliceous glasses exist in the presence of basic crystals such as hercynite ($FeO.Al_2O_3$). spinel ($MgO.Al_2O_3$), and many others that contain no silica, the association of siliceous glasses and basic crystals might seem unusual. The fact that these glasses do not crystallize is usually evidence of a relatively high silica content, for the viscosity of siliceous liquids favor their not crystallizing. The index of refraction of these uncrystallized interstitial materials is likewise some evidence of composition to the petrographer.

These glasses are sometimes referred to as slags. This is unfortunate, as the term *slag* is so general that it is not descriptive of anything except that it is something other than the principal iron-bearing constituent of the sinter.

The presence of siliceous glass is not easy to explain in the light of our knowledge of the system $CaO\text{-}FeO\text{-}SiO_2$ in which only wustite and an olivine would be expected. Although the index of refraction of an uncrystallized compound is almost always lower than that of the crystal of this composition, the glasses generally found in sinters seem to have too low an index of refraction to be uncrystallized olivine composition. It can only be assumed that they may result from local irregularities, poor mixing, inhomogeneity, or incomplete chemical reactions. It is not possible to determine the effect of Al_2O_3 in producing these glasses. The petrologist knows, however, that alumina is a *glass former* and encourages its formation. Heterogeneity here also is no doubt a factor in the existence of glasses in such systems.

A discussion of *slag* and glass in sinter should include the mention of fayalite. Fayalite is a mineral combining iron oxide and silica as follows: $2FeO.SiO_2$. The iron oxide content is 70 pct of the compound, a much higher proportion of iron oxide tied up with silica than is ever found in a siliceous glass. In a sinter in which a high percentage of fuel is used and in which reducing conditions and high temperatures must have prevailed, it is not surprising that there is fayalite present. Much has been said regarding fayalite in connection with blast furnace operation, but despite adverse comment there is little proof of any detriment to blast furnace operation caused by fayalite in the sinter.

Fayalite melts at 2200°F. Upon contact with an adequate amount of lime at this temperature as in the blast furnace it would immediately disappear through the following reaction:

$$2FeO.SiO_2 + 2CaO = 2CaO.SiO_2 + 2FeO$$

This reaction would seem to be favorable to blast furnace operation rather than unfavorable, as has been stated. According to T. L. Joseph,[2] fayalite is reduced in hydrogen at 1000°C (1832°F). Where this temperature exists in a blast furnace, the concentration of CO is high and no doubt between this temperature and the melting temperature of fayalite there would be good chance of its reduction taking place. If the objection of blast furnace operators to the presence of fayalite in sinter is actually directed toward excessive silica in the analysis of the sinter or excessive silica as evidenced by high percentages

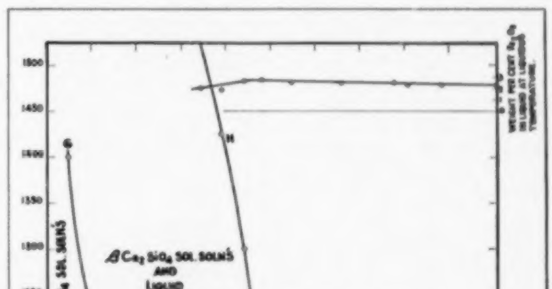

Fig. 2—Equilibrium diagram of the system $Ca_2SiO_4\text{-}Fe_2SiO_4$. (After Bowen, Schairer, and Posnjak, *American Journal of Science*, April 1933.)

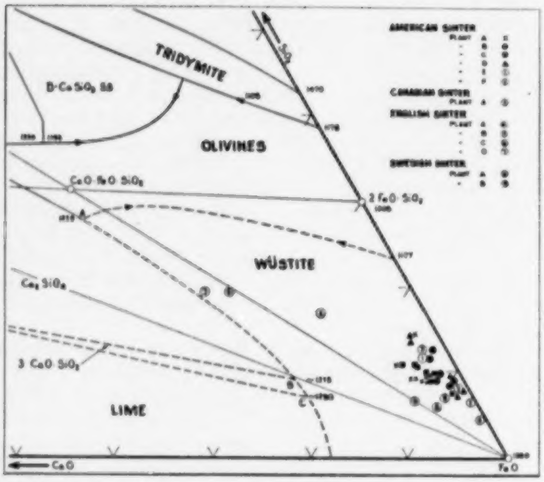

Fig. 3—Plot of sinters on CaO-FeO-SiO_2 diagram, MgO, MnO, and Fe_2O_3 included with FeO. These, with CaO and SiO_2, constituted 100 pct. Al_2O_3 omitted.

of siliceous gangue materials, the concern is acceptable and understandable.

The fayalite question should not be passed over too rapidly, and the fact that presence or absence of fayalite may be influenced by the atmospheric conditions existing in the sinter must not be neglected. When iron oxide and silica are melted under oxidizing conditions, as for example in the silica brick in the roof of an open hearth, magnetite and cristobalite or tridymite are the products found upon cooling. If fayalite is heated in air, again, magnetite and cristobalite or tridymite are formed. The presence of fayalite in sinter therefore is in itself indicative of a reducing atmosphere during melting and inadequate oxidation during cooling to form magnetite and cristobalite or tridymite. In such a case if a glass of very low index of refraction (1.46 to 1.48) were found in the sinter it could be assumed that the dissociation might have taken place without the crystallization of the appropriate silica mineral, but this has not been observed.

The question of lime is closely associated with that of fayalite. Many facets of the use of lime have been discussed. The chemistry of its use as applied to the mineralogy of sinters and slags is well known but should be discussed here.

Fayalite ($2FeO.SiO_2$) is the orthosilicate of ferrous iron. It is known as an olivine, a member of a group of minerals in which several other basic oxides, CaO, to a limited extent, MgO, and MnO may substitute for FeO. Lime is the most basic of these oxides, and when available in ample supply the orthosilicate of lime forms readily when proper temperatures prevail. This is the reaction which takes place when molten fayalite comes in contact with lime as described above. Where there is less lime than this available then silica combines with lime, iron, manganese, and magnesium oxide to form a more complicated olivine solid solution. As there is abundant iron oxide available in sinters, the system becomes as follows.

1—Where there is no lime, MgO, or MnO present the final product will consist of iron oxide (wustite) and fayalite.

2—With lime present but with a lime-silica ratio less than 1 the final result will be wustite and an olivine containing lime and iron oxide. (The olivine may contain also some MgO and MnO in addition to lime).

3—With a lime-silica ratio equal to 1, an olivine containing about equal proportions of lime and iron oxide (and possibly some MgO and MnO) will be present. (In this case iron oxide, manganese, and magnesium oxides are replaced to a larger extent by CaO than in point 2 above).

4—With a lime-silica ratio greater than 1 and less than 2, the minerals present in the final sinter would be wustite, an olivine approximately $CaO.FeO.SiO_2$, and dicalcium silicate. The "FeO" here may include some MgO and MnO.

5—With a lime-silica ratio equal to 2, the minerals present would be wustite and dicalcium silicate. The wustite would probably contain the MgO and MnO in solid solution.

According to Figs. 1 and 2, it is apparent that increasing amounts of lime beyond a certain point

Table I. Petrographic Analysis of Mineral Constituents of Sinter

Sample	Magnetite (Fe_3O_4)	Hematite (Fe_2O_3)	Olivine-Fayalite Silicate Series (CaO-FeO-SiO_2-2 FeO-SiO_2) Composition, Pct	Quartz (SiO_2)	Glass, Index	Ackermanite (2 CaO-MgO-2 SiO_2)	Gehlenite (2 CaO-Al_2O_3-SiO_2)	Siderite ($FeCO_3$)	Calcite ($CaCO_3$)	Total Carbon in Raw Mix, Pct
A*	M	m	m (F_2S)65 (C_2S)35	m	m 1.645	o		~	~	3.95 to 4.22
B*	M	s	L (F_2S)95 (C_2S)5	m	s 1.648	~	~	~	~	6.22 to 6.62
C*	M	s	L (F_2S)85 (C_2S)15	s	s 1.643	~	~	~	~	4.65
D†	M	m	m (F_2S)80 (C_2S)20	L	m 1.658	~	~	~	~	
E**	M	m	Possible s	L	m 1.675	~	m	m	~	
F**	M	s	Possible s	m	m 1.645	~	~	~	~	
G‡	M	L	m (F_2S)60 (C_2S)40	m	m 1.620	~	~	~	~	
H‡	M	L	m (F_2S)55 (C_2S)45	m	m 1.654	~	~	~	s	

* Bethlehem Steel Co. sinter.
† Another American sinter.
** English sinter.
‡ Swedish sinter.
F_2S = 2 FeO-SiO_2 (fayalite).
C_2S = 2 CaO-SiO_2 (dicalcium silicate).

M = Major constituent.
L = Large amount.
m = Moderate amount.
s = Small amount.
o = Occasional grains.

would have the general effect of raising the melting temperature of the olivine phase which includes the minor constituents. In fact, when the lime-silica ratio is equal to 2, the wustite-dicalcium silicate combination is very refractory and *dry* and may be quite weak. It might also *dust* because of the inversion of dicalcium silicate from its beta to gamma form. Dusting is therefore not to be mistaken for slaking of lime. Slaking of lime has been known to occur in sinter mixtures wherein the lime or limestone addition was too coarse-grained to become fluxed, and only calcined during the sintering operation.

The System, CaO-FeO-SiO₂, by Bowen, Schairer, and Posnjak,[3] illustrates the trend toward higher melting temperature in this system in the direction of dicalcium silicate and lime.*

* The authors have developed a lucid method of presentation showing the areas which are liquid at various temperatures. The diagrams are of particular interest to anyone interested in the chemistry of sinter.

Fig. 3 shows a plot of a number of sinters on the $CaO\text{-}FeO\text{-}SiO_2$ diagram. These sinter compositions were calculated to a 100 pct basis with the MgO and MnO included in the FeO. Only CaO, SiO_2, FeO, MnO, and MgO are included. If a line is drawn from the FeO corner through any of these sinter compositions, the point where the line intersects the CaO. $FeO.SiO_2$—fayalite join represents the composition of the olivine that should exist in the sinter. The lime-silica ratio of the sinter composition controls the point of intersection and therefore the composition of the olivine phase. The sinters plotted on Fig. 3 seem to vary in composition only slightly, but it will be apparent when one follows the above use of the phase diagram that sinters containing different kinds of olivine as the silicate phase will be found. Table I shows what was actually found in sinters examined at Bethlehem Steel Co. Table II is a chemical analysis of sinters reported in Table I.

Table II. Chemical Analysis of Sinters Reported in Table I

Chemical Constituents, Pct	A*	B*	C*	D†	E**	F**	G‡	H‡
Total Fe	56.16	59.60	58.04	59.00	35.80	64.00	61.10	57.70
SiO_2	8.84	7.92	10.84	17.70	16.30	7.15	5.35	6.00
CaO	3.68	0.20	1.26	3.60	18.40	0.66	4.10	5.80
MgO	2.08	0.48	0.39	1.30	2.16	0.50	1.35	3.13
MnO	0.86	0.39	0.99		1.20	0.30	1.55	1.36
S	0.01	0.01	0.02		0.15	0.01	0.02	0.01

* Bethlehem Steel Co. sinters.
† Another American sinter.
** English sinter.
‡ Swedish sinter.

Discussion of the magnetic properties of sinters must not be omitted. Not all magnetic iron is magnetite. In sinters produced from magnetite concentrates it is possible to have magnetic gamma Fe_2O_3 maghemite. Care should always be exercised in calling such magnetic constituents magnetite solely on the basis of a magnetic test.

In conclusion, it should be emphasized that while details of the foregoing discussion of the mineralogy of sinter have been verified by petrographic examination in sinters of which samples were available, sinter is a more or less heterogeneous result of relatively incomplete chemical reactions. This must always be borne in mind when the mineralogy of a sinter is being discussed, since there may be other factors having equally important bearing on physical properties.

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Discussion*

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* TP 3674

A — Metal Mining

An Analysis of Mine Opening Failure by Means of Models

by Bernard York and John J. Reed

DISCUSSION

Louis A. Panek *(College Park, Md.)*—The authors have chosen a problem that merits considerable study, because the phenomenon of failure of rock in the vicinity of an underground opening is important, although far from being adequately understood.

It is interesting to find that the model cracks appear to coincide with the trajectories of maximum shearing stress when the opening exists in a body subjected to hydrostatic pressure. It would be instructive to determine whether this is true for unidirectional loading as well.

It may be true, under certain conditions, that the larger the opening in rock or a similar material, the weaker the opening. The writer cannot agree, however, that this conclusion is supported by the experimental results. Fig. 12 suggests that this rule does not apply to openings more than about 1.5 in. in diam. Since a 1.5-in. opening has little importance in mining, if Fig. 12 is to be capable of practical application, it must be considered to give the results of testing scale models that represent the behavior of much larger openings, and the well known requirements as to similarity between a model and its prototype must be satisfied. To calculate the size of mine opening represented by such a model it is necessary, in general, to determine the scale ratio (ratio of a prototype dimension to the corresponding model dimension). The conclusion that "the larger the opening the weaker it is" implies that this is true for openings of any size, i.e. that this holds true for all values of the scale ratio. By arbitrarily choosing scale ratios of 240 and 384 and model openings of ¾ in. and 1 in., as shown in the accompanying table, it can be "proved" that since a 1-in. model opening is weaker than a ¾-in. opening, therefore a 20-ft mine opening is weaker than a 24-ft mine opening. This obvious inconsistency serves to illustrate the fact that actually the scale ratio may not be arbitrarily chosen. If the scale ratio is indeterminate, as is apparently the case, it is impossible to specify the size of mine opening represented by any model hole smaller than 1.5 in.; hence the results obtained for model holes smaller than 1.5 in. cannot be applied to mine openings. Fig. 12, therefore, indicates that the model holes should be at least 2 in. in diam in order to represent mine openings; a free choice of scale ratio can then be made, since size will have no effect on the strength of the opening. Moreover, with the larger opening a difference in strength between a square and a circular shape may be exhibited. An alternative is to determine the dimensional relationship between "the incipient cracks or other weaknesses in the (model) material" and those in the mine structure, and determine the scale ratio from this relationship. The size of mine opening represented by any model hole could then be calculated.

Size of Model Opening	Size of Prototype Opening	
	Scale ratio = 240	Scale ratio = 384
¾ in.	15 ft	24 ft
1	20	32

B — Minerals Beneficiation

Magnetic Roasting of Lean Ores

by Fred D. DeVaney

DISCUSSION

W. O. Philbrook *(Carnegie Institute of Technology, Phila.)*—Mr. DeVaney's paper is a valuable addition to the growing technology of the magnetic roasting of lean iron ores. His furnace is ingeniously designed to permit close control of the process and to achieve high thermal efficiency by counter-current heat exchange and the withdrawal of both solid and gaseous products at relatively low temperatures. The principle of using a lean reducing gas to avoid over-reduction of the ore even at high operating temperatures (for rapid reaction rate) is thoroughly sound. The gas analyses and flow rates reported, however, are internally inconsistent and render suspect any details of a heat balance based upon them. While it is entirely proper to consider the entrant gas as a reagent and to account only for the heat evolved by consuming a portion of the gas, many operators are accustomed to a heat balance using the total calorific value of the reagent supplied; and comparison of heat balances made with different bases of calculation can be quite misleading. Since Mr. DeVaney's paper is likely to be cited frequently in future discussions of magnetic roasting processes, it seems worth while to point out the internal discrepancies and to give alternate values of heat requirements for different bases of calculation.

The statement is made on p. 1222 that "because of air leakage 32.6 pct of the gas was burned in the furnace," and a heat evolution of 126,600 Btu per ton of feed was attributed to this combustion. This assumption of air leakage was required to obtain a CO balance for the reported analyses and flow rates of entrant and exit gases, but it will be shown that it cannot be supported by total material balances for individual chemical elements. Furthermore, it seems physically impossible that there should have been any significant air leakage into a furnace operating above atmospheric pressure, and the reported air supply to burn the fuel oil is, if anything, a trifle less than the theoretical requirement. The premise that reagent gas was burned by air within the furnace cannot be proved by the evidence available.

Before the inconsistencies of the data may be demonstrated, it is necessary to make some reasonable assumptions on points not clearly defined in the paper. "Standard conditions" for gas volumes are assumed to be 60°F, 30 in. mercury pressure, dry, under which conditions a pound mol of perfect gas occupies 379 cu ft. On this basis, the amount of CO required to reduce a pound of iron in the form of hematite to magnetite is 1.13 cu ft, instead of 112 cu ft as stated on p. 1222. The analyses and flow rates of the exit gases shown in Fig. 4 of the paper are ambiguous in that a wet analysis is given for gases leaving the furnace, but the flow rate for the moist recirculated gas is the same as given for dry recirculated gas leaving the scrubber and entering the bottom of the furnace, namely 385 cfm. It will be assumed that reported flow rates refer to dry gases in all instances.

To be consistent with the thermal data reported, the fuel oil is assumed to have the following properties: 30°API, 7.29 lb per gal; heating value 19,450 Btu per lb (gross); 18,310 Btu per lb (net), 133,500 Btu per gal (net). A reasonable analysis would be 86 pct C, 12 pct H, 2 pct O + N + S + ash. On this basis the theoretical air requirement for 1.5 gal per hr of oil is 5.30 mols per hr or 33.5 cfm (as compared with 33 cfm reported), and the theoretical products of combustion are 0.78 mols CO_2, 0.66 mols H_2O, and 4.19 mols N_2.

The iron content of the feed and products, calculated from the weight and analysis of the roasted ore, is taken to be 650 lb Fe per hr. This is equivalent to 929 lb of Fe_2O_3 in the feed, 898 lb of Fe_3O_4 in the product, and 31 lb O or the equivalent of 0.97 mols O_2 removed by the roasting process. The moisture evaporated from the feed is 78.4 lb or 4.35 mols H_2O per hr.

Material balances may now be made for total quantity of gases and for individual elements. The recirculated gas may be dropped from the balances, except for moisture calculation, since Fig. 4 shows the same volumes and same *dry* analyses of recirculated gas leaving the top and entering the bottom of the furnace. It should be noted that there is no change in volume when CO is oxidized to CO_2 by oxygen from Fe_2O_3, but oxidation of CO by air would entail the introduction into the gas of N_2 equivalent to 3.76 times the volume of O_2 consumed or 1.88 times the volume of CO converted to CO_2. For a perfect gas (at 60°F, 30 in. Hg, dry) mols per hr = cfm × 60/379, and the individual constituents are calculated from gas analyses and flow rates. Equivalent mols C = mols CO + mols CO_2, and equivalent mols O_2 in gas = ½ mols CO + mols CO_2. An element balance is given in Table II in which the reported gas analyses and flow rates are used as the basis of calculation, ignoring any leakage air and assuming theoretical products of combustion of oil.

Table II shows that the vented stack gas is too low in C, O_2, and H_2O to account for the input, but far too high in N_2. The addition of leakage air to the input to bring the N_2 figures into balance would throw the oxygen balance still farther out of line. Without giving the detailed calculations, it is sufficient to say that a balance for N_2 requires 7.18 mols of leakage air; a balance for the volumetric flow of entering gases to be consistent with the volumetric flow rate of stack gas (both on a dry basis) requires 5.7 mols of leakage air; and a CO balance (ignoring discrepancies in the C balance) requires 2.74 mols of leakage air. If the gas analyses were internally consistent, it would be possible to solve simultaneous equations for C, O_2 and N_2 balances to obtain the volumes of producer gas, air, and stack gas, but such an attempt leads to inconsistent and ridiculous answers. Obviously the gas analyses and reported flow rates are seriously inconsistent and will not support any material or heat balance calculations based upon them.

Table II. Element Balances, Mols per Hr

Input	CO	CO_2	Equiv. C	Equiv. O_2*	H_2O	N_2
Producer gas	3.39	0.31	3.70	2.01		6.59
Products of comb. of oil		0.78	0.78	0.78	0.66	4.19
Ore, drying + reduction				0.97	4.35	
Total			4.48	3.76	5.01	10.78
Output						
Stack gas	0.30	3.05	3.35	3.20	4.25†	16.45

* Equivalent O_2 in carbon oxides and from ore, but not including H_2O.

† Assuming 510 cfm *dry* exit gas, 5 pct H_2O on moist basis:

$$\frac{510}{0.95} \times 0.05 \times \frac{60}{379} = 4.25 \text{ mols } H_2O.$$

Turning now to heat balance calculations, it is evident that an item for heat released by burning a portion of the entrant gas within the furnace is, at best, uncertain. There is little justification for a detailed heat balance including sensible heats in entrant and exit gases because the volumes of the gases involved are not reliable. This is not a serious defect, however, because the heat contents of entering gases seem to be a by-product of the energy of compressing them, and the temperature of the exit materials is so low that further recovery of heat from them would be impracticable. It should be sufficient for practical purposes to characterize the heat balance by the external heat required.

No heat balance can be properly calculated until the system and the basis for calculation have been defined. It is quite proper to limit the system to the furnace itself and to consider the producer gas as a chemical reagent (not as a fuel) as Mr. DeVaney has done. In this event, however, the exothermic heat of the reaction

$$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$

should properly appear in the "input" side of the heat balance to account for reagent consumed. Using the best available data,[1] the ΔH of this reaction is -12.1_5 k cal or 21,880 Btu evolved for 2 lb mols Fe_3O_4, which amounts to 47.2 Btu per lb Fe_3O_4 formed, instead of 88 Btu as stated by DeVaney on p. 1220. A balance which includes only the net heat actually evolved in the process is the best for analyzing the distribution of heat within the process, but it may not be suitable for comparison of one process with another for which a different basis of calculation was used.

In order to compare the heat requirements of the DeVaney process with some other type of reducing roast for which the total heating value of the reagent has been considered as "heat supplied," it is necessary to put the thermal calculations all on the same basis. One possibility is to define the system to comprise the furnace and oil burner and to include the calorific value of the producer gas as well as of the oil in heat supplied. Another possibility is to include the gas producer within the system and consequently to consider the calorific value of the coal or coke fed to the producer as heat supplied. In either event, since the calculation implicitly assumes burning all C or CO to CO_2 in some fashion, the appropriate heat of reaction is for

$$3Fe_2O_3 \rightarrow 2Fe_3O_4 + \tfrac{1}{2}O_2,$$

which is endothermic to the extent of 216 Btu per lb of Fe_3O_4 and should appear under "heat consumed."

The heat input to the DeVaney process according to each of the three methods outlined is given below. It has been necessary to accept the analysis of the producer gas and the flow rate of 65 cfm given in Fig. 4, and the amount of carbon fed to the gas producer has been calculated because of the absence of any statement of coal or coke consumption. The calculated thermal requirements are rather uncertain, therefore, but they are the best that can be obtained from the experimental data supplied.

Table III. Heat Supplied to DeVaney Process

For 1 ton of feed; sensible heats neglected; base temperature 25 C (77°F); H_2O (g) as standard state.

Basis A: System comprises furnace only. Producer gas is treated as reagent without regard to its calorific value.	
Heating value (net) of oil: 1.5 x 133,500	200,000 Btu
Heat of reaction: 47 Btu per lb Fe_3O_4 x 898 lb Fe_3O_4	42,000
Total input	242,000 Btu
Basis B: System comprises furnace only; calorific value of producer gas as a fuel considered as a cost of the process.	
Heating value (net) of oil: 1.5 x 133,500	200,000 Btu
Heating value of producer gas: 65 ft³ per min x 60 min per hr x 0.33 CO x 321 Btu per ft³	410,000
Total input	610,000 Btu
Basis C: System includes gas producer; calorific value of coke fed to producer considered as a cost of the process.	
Heating value (net) of oil: 1.5 x 133,500	200,000 Btu
Heating value of carbon to producer: $\frac{65\times60}{379}\ \frac{\text{mols gas}}{\text{hr}} \times \frac{0.36 \text{ mols C}}{\text{mol gas}} \times \frac{12 \text{ lb C}}{\text{mol C}} \times \frac{14{,}600 \text{ Btu}}{\text{lb C in coke}}$	650,000
Total input	850,000 Btu

The difference between Bases A and B in Table III rests in a different viewpoint as to "heat of reaction" plus heating value of unconsumed CO in the stack gas. The difference between Bases B and C represents partial combustion of C to CO and CO_2 in the gas producer plus heat losses in the producer. The choice of basis depends upon the use to be made of the results.

It is not the intention of this discussion to discredit Mr. DeVaney's contribution. Considering the difficulties of metering gas flows accurately under conditions of varying temperature, pressure, and composition, and the low precision often inherent in Orsat analyses, it is a difficult task to obtain valid material balances under the conditions of this process. It is hoped that this discussion may add to the inherent worth of Mr. DeVaney's paper by giving a clearer perspective for comparing it with other magnetic roasting processes.

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Effects of Alkalinity on the Flotation of Lead Minerals

by Marston G. Fleming

DISCUSSION

E. C. Peterson *(Anaconda Copper Mining Co., Darwin, Calif.)*—A study of this quite comprehensible and interesting paper by Dr. Fleming brings to mind several observations in the practical application of alkalinity and related factors to the actual practice of lead mineral flotation.

Soda ash has long been a widely used and a very helpful alkaline conditioning agent in the flotation of galena from the usual run of lead-zinc ores. Soda ash is one of the common "standard" conditioning agents tried in any laboratory investigation of lead-zinc ores because it has so often proved helpful to galena flotation. However, the use of soda ash in the actual flotation of oxidized lead ores is certainly not widespread.

In the flotation of certain lead-zinc ores from the Park City district of Utah, it was found in the usual cyanide-zinc sulphate-xanthate circuit that soda ash had an effect of producing a very condensed and flat froth regardless of the many frothers tried and that substitution of lime for soda ash to produce the same pH (8.0 to 8.4) improved the froth condition. However, the flotation of coarse particles of galena became so critical that some would pass through into the tailing, but caustic soda as a substitute for either soda ash or lime produced a very desirable froth condition in the same pH range and greatly improved the metallurgical outcome. Milling was carried out in typically "hard water" from watersheds of limestone and other calcareous rocks and the ore also apparently contributed magnesium and calcium salts to the pulp.

Certain lead-zinc ores of Mexico have shown their greatest flotation response in circuits conditioned with sodium bicarbonate, and such actual mill use was also believed to be related to the water necessarily used in milling. On other lead-zinc ores the optimum has been obtained in actual milling treatment by use of caustic soda in both circuits of the operation.

In flotation of oxidized lead ores in which sulphidization is employed by addition of sodium sulphide, very high pH's exist in the flotation circuit. With the usual oxide lead ores, demanding 5 to 15 lb of sodium sulphide per ton of ore, pH's in the circuit (closed and open water-circuits) may range from 9.5 to 12, and for ores that contain much anglesite or a high percentage of iron oxide minerals, sodium sulphide consumption may reach as much as 30 lb per ton of ore and the resultant pH will be correspondingly higher. Yet in such flotation treatment employing either xanthate or oil (high-sulphur crude oil or diesel oils) as the collector, satisfactory to excellent grades of concentrate and lead recovery are obtained.

Although there have been great studies and accomplishments in the investigations of flotation fundamentals and flotation theory, and although an investigation to determine the effect of all factors entering into the actual plant flotation of sulphide and oxide ores must become very complicated, as Mr. Fleming has mentioned in his caution regarding the drawing of general conclusions for other ores, it seems that it would be of greater interest if the techniques and investigations could, with time, approach the conditions of actual practice and lead the way to improved and more efficient flotation plant performance.

Marston G. Fleming (author's reply)—The gulf between fundamental flotation research and plant operation is, perhaps, less wide than Mr. Peterson suggests. For example, the work described in my paper developed from an extensive investigation of a complex lead-vanadium ore from southwest Africa. This investigation started as a standard ore-testing problem but, at almost every stage, results were obtained which could not be interpreted in terms of previous experience. A program of fundamental research was therefore undertaken and was closely interlocked with the ore testing. This coordinated investigation resulted in a flotation process which has now been proved by two years of successful plant operation, and although the grade and mineralogical constitution of ore as well as smelter requirements have altered more than could have been anticipated, our knowledge of the fundamental character of the problem has made it possible to meet each change in conditions with much more confidence than would have been the case had we neglected this aspect of the investigation.

Upgrading of Low Grade Manganese Ores by Leaching with Caustic Soda

by R. V. Lundquist

DISCUSSION

L. A. Roe *(Bjorksten Research Laboratories, Inc., Madison, Wis.)*—This paper is typical of the current trend of thought in the mineral beneficiation industry. As we focus our attention on the more complex and the lower grade ores we find, in many cases, that older methods of beneficiation are either too costly or do not apply at all. With the exception of methods of comminution, there is little hope that we can greatly increase efficiencies of the various unit processes currently used to beneficiate ores. Our great hope is in new methods of beneficiation, and heading this list are "chemical beneficiation 'methods.'" It is often said that the inorganic chemists have failed to keep pace with the organic chemists. When we observe the progress of the plastics, petroleum, and medicinal fields there seems to be considerable evidence that this is true. Now when we turn to the mineral beneficiation industry it is only too evident that we have failed to keep pace with either the organic or the inorganic chemists in applying new chemical theories and techniques to our field. Our main excuse has been that we cannot afford these expensive chemical methods except in the case of the rare and precious metal ores. With the advent of large-scale processing of low-grade magnesium, aluminum, nickel, and uranium ores by chemical methods it is to be hoped that in the near future we will see the spread of similar methods to process iron, tin, manganese, and many other ores.

I wish to offer information which will supplement the evidence presented by this paper as regards the value of caustic leaching of silica from ores. Using low-grade Michigan iron formation composed chiefly of goethite and chert, I have applied the principles set forth in this paper with the exception that higher pressures and temperatures were used. The results listed below show how effectively this chemical beneficiation method can upgrade iron ores:

	Fe, Pct	SiO_2, Pct
Original iron formation	36.09	44.72
Processed iron concentrate	60.33	6.54

The crude ore used in the above test was ground in a ball mill until the ore was 85 pct −200 mesh. The leaching operation was carried out at 200°C and 200 lb per sq in. of pressure in a cast-iron autoclave. Only one stage of leaching was used. The potentialities of the method in producing extremely high grade iron concentrates for use in the production of powdered iron are great.

Measurement and Evaluation of the Rate of Flotation as a Function of Particle Size

by T. M. Morris

DISCUSSION

R. T. Hukki *(Finland Institute of Technology, Helsinki, Finland)*—Two schools of thought are developing concerning the order of the rate of flotation. The paper by Morris is intended to show experimental evidence in favor of the first order rate.

Arbiter, on the other hand, has presented an earlier paper[10] to demonstrate the validity of the second order rate equation. Unfortunately his method of plotting is open to criticism, as pointed out by Morris.[11] A more sensitive method of plotting has been described by the writer,[12] whereby the data presented by Arbiter demonstrate the superiority of the second order plot.

The general rate equation may be written in the following forms for the integrated first and second order equations:

$$\text{(A)}\quad t = -\frac{1}{k}\ln\frac{C_o - R}{C_o} \quad \text{(first order)} \qquad [4]$$

$$\text{(B)}\quad \frac{1}{t} = -kC_o + kC_o^2\frac{1}{R} \quad \text{(second order)} \qquad [5]$$

As a first approximation the value of C_o may be taken as a unity, 100 pct or 1. Whether or not this is the case in all tests performed by Morris is impossible to judge, owing to the fact that the flotation times are extremely short, e.g. 150 sec in tests A. It would, indeed, be very interesting to know what the total recovery R would be after 1 hr of flotation, for example, instead of after 150 sec. Certainly there are circumstances when C_o approaches unity within a very small margin of error. Morris has used the same approximation in his example D "since the feed to this cleaner

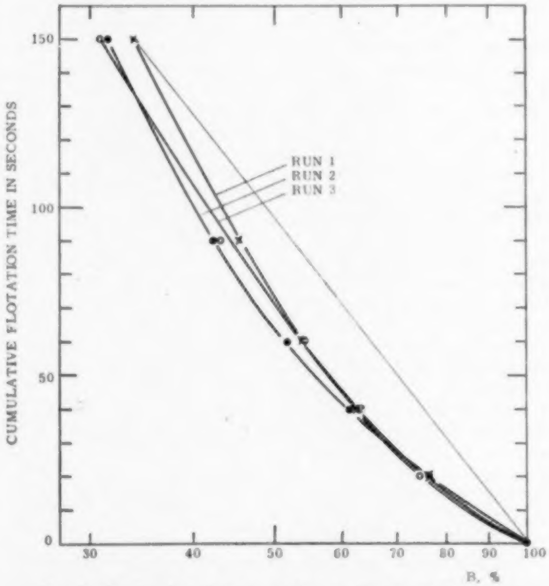


Fig. 8—First order plots according to Eq. 6 of the uncorrected data by Morris.

machine consisted of particles which had floated in the preceding rougher operation." In tests A he used "cleaned concentrate made from Tennessee Copper Co. ore." No information was given as to the prehistory of the method of cleaning. In this particular case, however, Morris has had to use a factor x to prove what he intends to prove.

Morris bases his thesis on the idea that flotation rate data must give a straight line by the method of plotting he adopts. To make the method work, he needs the crutches provided by factor x. Factor x, the value of which is omitted except in one example, varies according to numerous variables. It must be found by trial and error. By use of proper scales, the plots finally appear relatively straight.

The scientific validity of the method is something to question. By exercise of similar patience the second order plot given by Eq. 5 can also be shown to give a straight line with selected data and with proper factor x. In the writer's opinion this proves nothing.

An interesting feature in the paper by Morris is the study of flotation rates in relation to size fractions. At the same time, however, he overlooks the difference in relative floatabilities of pyrite and pyrrhotite and reports the final recovery in grams in tests A. Perhaps the method of analysis described by McLachlan[18] would have been an additional useful tool in the evaluation of products in tests A.

To demonstrate the limitations of the method presented by Morris the writer would like to present a re-examination of part of the evidence cited by Morris.

First order plot: The first approximation of Eq. 4 may be written as

$$t = -\frac{1}{k}\ln(1-R) = -\frac{1}{k}\ln B \qquad [6]$$

It is seen from Eq. 6 that graphical representation of flotation time vs recovery in tailing ($1-R$ or B) should form on a semilogarithmic paper a straight line passing through the point $t = O$, $B = 1$ providing the flotation process follows the first degree rate equation.

Accompanying Table V gives the original data by Morris (his Table I) and Fig. 8 shows the respective first order plots.

Second order plot: By giving factor A again the value of unity Eq. 2 can be given as

$$\frac{1}{t} = -k + k\frac{1}{R} \qquad [7]$$

or

$$1 + kt = \frac{1}{B} \qquad [8]$$

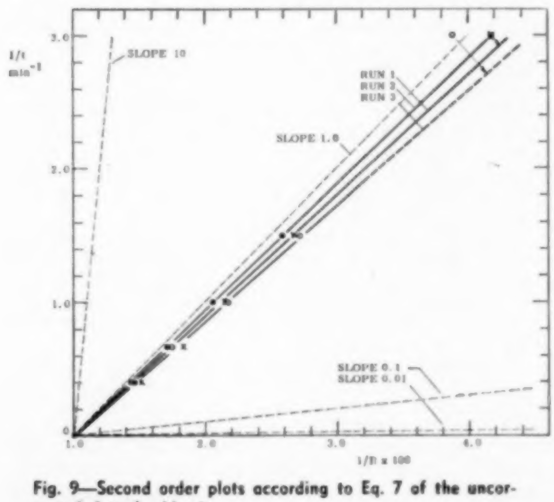


Fig. 9—Second order plots according to Eq. 7 of the uncorrected data by Morris.

It is seen from Eq. 7 that as the flotation time becomes infinite, the ratio $1/t$ becomes O and the ratio $1/R$ becomes 1. Thus the experimental flotation results, when plotted as $1/t$ against $1/R$, should form a straight line passing through the point $1/t = O$, $1/R = 1$, intercepting the O— ordinate at the negative value of the rate constant and having the slope of the same positive numerical value as the intercept, all this under the condition that the flotation process follows the second degree rate equation. Eq. 8 indicates that by plotting the reciprocal of the diminishing recovery of the valuable mineral in tailing against cumulative flotation time, a straight line relationship should again be obtained. This method of plotting is more sensitive than the preceding one toward the end of flotation.

Data by Morris for graphical presentation according to Eq. 7 are given in Table VI and according to Eq. 8 in Table V. The respective plots are shown in Figs. 9 and 10.

The evidence given above indicates:

1—The data do not satisfy the requirements of the first order rate equation, because the plots are definite curves.

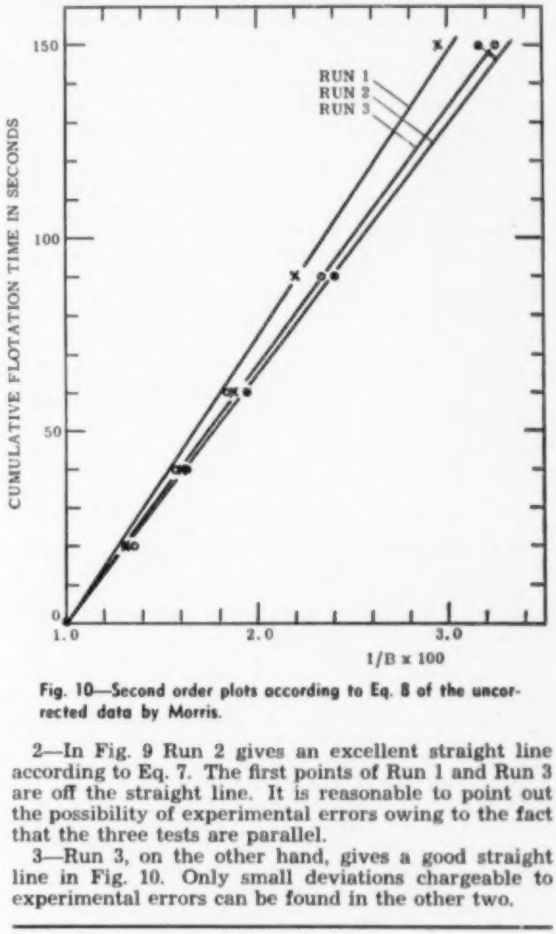


Fig. 10—Second order plots according to Eq. 8 of the uncorrected data by Morris.

2—In Fig. 9 Run 2 gives an excellent straight line according to Eq. 7. The first points of Run 1 and Run 3 are off the straight line. It is reasonable to point out the possibility of experimental errors owing to the fact that the three tests are parallel.

3—Run 3, on the other hand, gives a good straight line in Fig. 10. Only small deviations chargeable to experimental errors can be found in the other two.

Table V. Results of Test A

	Cumulative Time,	Cumulative Weight of Tailing, Pct (B)			1/B x 100		
Pan	Sec	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
1	20	76.1	76.1	74.2	1.31	1.31	1.35
2	40	62.6	61.3	63.2	1.60	1.63	1.58
3	60	53.5	51.4	54.0	1.87	1.94	1.85
4	90	45.4	41.6	42.7	2.20	2.40	2.34
5	150	33.9	31.6	30.8	2.95	3.16	3.25

Table VI. Results of Test A

Pan	Cumulative Time, Sec	$1/t$, min^{-1}	Cumulative Weight, Pct (R)			$1/R \times 100$		
			Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
1	20	3	23.9	23.9	25.8	4.18	4.18	3.88
2	40	1.5	37.4	38.7	36.8	2.67	2.59	2.72
3	60	1	46.5	48.6	46.0	2.15	2.06	2.17
4	90	0.67	54.6	58.4	57.3	1.83	1.71	1.74
5	150	0.40	66.1	68.4	69.2	1.51	1.46	1.44

4—Data in Table II by Morris give evidence similar to that discussed above. The finer fractions show less perfect plots, because of cumulative errors. This is not visible in figures prepared by Morris.

5—Longer flotation times are highly desirable to demonstrate the true total recovery.

From previous experience the writer would like to point out that:

1—He has not found a single set of data to give reliable support for the first order rate equation.

2—He has found about one third of all experimental evidence available in published results by other investigators favorable for the second order relationship.

3—The slope of the second order plot, Fig. 9, is a useful *flotation rate index,* the numerical value of which increases with improving performance, e.g., 0.01 for very slow; 0.1 for slow; 1 for normal; and 10 for very fast flotation.

4—Flotation rate tests should be conducted with automatic flotation apparatus to be dependable. Only then can the statement be justified that "the real test of the graphical method is whether or not the earliest points agree with a straight line."[11]

5—Flotation rate studies may never be conclusive enough to prove exclusively the validity of the first or second order rate process.

[10] N. Arbiter: *Trans.* AIME (1951) **190**, p. 791.
[11] T. M. Morris: *Trans.* AIME (1951) **190**, p. 991.
[12] R. T. Hukki: Flotation Rate and Flotation Rate Index. *Suomen Kemistilehti* (1952) **B 25**, pp. 29-35.
[13] C. G. McLachlan: *Trans.* AIME (1934) **112**, pp. 570-596.

T. M. Morris (author's reply)—The remarks made by Mr. Hukki are appreciated. His main criticism seems to involve my use of a factor to evaluate the percentage of floatable material in a flotation operation.

The law of mass action states that the "rate of a chemical reaction is proportional to the 'active mass' of the reacting substances present at any given time."

The determination of active mass is necessary not only in rate studies, but also in thermodynamic calculations where the term activity is used in place of active mass. Therefore it is no more permissible to assume all of the mass as active in a rate study than it would be to assume activity to be unity in a thermodynamic calculation.

Hence any analysis of flotation rates which assumes that all of the solid particles will float is unrealistic and the law of mass action is violated.

Probably the most practical method for evaluating the percentage of floatable solids is to continue the flotation operation until no particles of the mineral to be floated report in the froth. In a batch cell this method must sometimes be used with caution as explained on page 797 of my paper.

I agree with Mr. Hukki that graphical presentation of flotation rate studies probably will not be conclusive enough to prove the order of the rate. The use of a flotation rate equation should prove a useful tool in the study of flotation operations.

Sampling and Testing of Sinter

by R. L. Stephenson and D. J. Carney

DISCUSSION

M. O. Holowaty *(Inland Steel Co., Chicago)*—Messrs. Stephenson and Carney should be commended on the presentation of this very interesting paper. They have introduced new ideas on sampling of sinter and have thereby made a valuable contribution to the qualitative evaluation of sinter. The paper undoubtedly presents a novel approach to the problem of sinter sampling and this is to be regarded as its main value.

Sampling of sinter from the pallets prior to the discharge is by no means new. This sampling procedure was used in the past by Philbrook,[3] Hamilton and Ameen[4] and others. The sampling basket used by the authors of this paper, however, permits one actually to obtain a good sample of the sintering mixture. The basket which can also be described as a removable pallet goes then through the entire process of sintering and thus offers a sample which is positively representative of the batch in question.

The authors' method of evaluating physical properties of sinter seems to be not altogether clear, however. It is felt that the following points should be clarified:

1—In the section describing the shatter test the authors state that a 5-lb sample was used in the actual tests. There is no mention of the initial size of sinter particles used and the method of obtaining this 5-lb sample from the sinter cake weighing about 100 to 120 lb. It is also surprising that the sample was dropped from a height of 3 ft instead of the conventionally used 6 ft. Unfortunately there is no mention of the number of drops to which the sample was subjected.

2—The tumbler test used by Messrs. Stephenson and Carney in testing the samples of iron ore sinter was performed in a standard ASTM coke tumbling drum. The drum measures 3 ft in diam and is equipped with two 2-in. lifter bars. The distance of fall in this testing drum is identical with the distance used in the previously described shatter test. The number of drops in the tumbling drum is approximately double the number of revolutions. The basic difference then between the drop-shatter test used by Stephenson and Carney and the tumbling test seems to be the number of drops to which the sample is subjected and the abrasive action to which the sinter particles are exposed in the rotating drum. In any case, the choice between the shatter test and the tumbler test seems to be only a matter of taste and convenience.

3—The authors of the paper state that "in order to insure getting results that were representative . . . the entire sample obtained by means of the sampling basket was used as the starting material for the tumbler test. If the sample broke in pieces, all the pieces were used regardless of their size."

The initial size of the material is known to be a very important factor, influencing seriously the final size of the particles. This should be particularly important in case of hard sinters. It seems also very troublesome and inconvenient to charge 12-in. cubes of sinter weighing about 100 lb into the testing drum. This could be eliminated by taking a standard fraction of somewhat smaller particles.

4—Messrs. Stephenson and Carney use Power's method to express the results of sieve analyses used in the evaluation of the material degradation following the strength test. Power's method involves plotting the size of the sieve openings on a logarithmic scale and the cumulative percentage of material retained on each screen on the probability scale. The median size is derived from the graph by interpolating the plotted data and calculating the opening size of the screen on which 50 pct of particles would be retained.[5]

This method has serious disadvantages. Let us consider, for example, two sinters, A and B. A is a medium hard sinter. In the strength test it breaks up into particles of various sizes with values evenly distributed over the whole range on the graph of the screen analysis. B is a spotty, partially burnt sinter. The product of the strength test performed on this sinter contains a small percentage of hard, slaggy lumps and a high percentage of unagglomerated fine material. The plotted values of the screen analysis shows in this case no change in cumulative percentage of material retained on the succeeding screens. The median sizes derived from the plots of the screen analyses of the two products may then give identical values without revealing the difference in the physical structure of the material.

It seems obvious that these two sinters cannot possess the same strength and that their performance in the blast furnace will be entirely different. It would seem advisable to express the results of a strength test in another clearer way.

The method used by Voice, Lang, and Gledhill, for instance, seems to be quite convenient.[6] According to this method the strength index is expressed as the percentage of material un-degraded in the test and as the percentage of —⅛ in. fines generated during the test. The latter is also called *dust index*. The particle sizes chosen as criteria of strength in the method of Voice and associates could be modified to conform with the opinions of our blast furnace people who generally regard material finer than 20 mesh as too fine. This is, however, only a suggestion and some other method might be preferred.

I think that clarification of the issues raised will provide some of the answers needed to establish a good, dependable method for qualitative evaluation of sinter. This method based on the Stephenson and Carney sampling procedure could develop into a standard sinter testing procedure which might be eventually accepted by the whole United States iron ore sintering industry.

[3] W. O. Philbrook: *Blast Furnace and Steel Plant* (1943) 31.
[4] F. M. Hamilton and H. F. Ameen: Laboratory Studies on Iron Ore Testing and Sintering. *Trans.* AIME (1950) 187, p. 1275.
[5] R. E. Powers: Yearbook AISI (1951).
[6] E. W. Voice, C. Lang, and P. K. Gledhill: *Journal of Iron and Steel Institute* (1951) 167.

R. L. Stephenson and D. J. Carney (authors' reply)—We appreciate Mr. Holowaty's comments on this paper, and we hope we will be able to clarify the points he enumerates. In the following discussion, the individual points are numbered in the same order as in Mr. Holowaty's discussion.

1—Some of the confusion, we believe, has arisen from the fact that only 5-lb samples were used in the preliminary experiments in which the shatter test was compared with the tumbler test, whereas the sample size selected for the final tumbler test was approximately 100 lb. The reason that only a 5-lb sample was used in the preliminary experiments was that separately procured 100-lb basket samples might not be identical and would not constitute suitable starting samples for comparing two degradation tests. To provide samples as nearly identical as possible for comparing the two testing procedures a 500-lb sample was procured from the sinter cooler. This large sample was separated into various size fractions which were in turn riffled into smaller samples. The comparison was run with samples containing pieces of sinter between 1 and 2 in., and also with samples containing pieces of sinter between ½ and ¾ in.

Although the drop test was limited to 16 drops, to avoid the excessive amount of work that would be required if a greater number of drops were employed, the effect of using an intermediate number of drops was also investigated. For 4, 8, 12 and 16 drops, the per cent of sinter coarser than each sieve was approximately inversely proportional to the logarithm of the number of drops to which the sinter was subjected.

2—The final selection of the tumbler test, as Mr. Holowaty pointed out, was based to a certain extent on the fact that this test was the most convenient method for doing the job satisfactorily.

3—It is true that initial particle size is an important factor influencing the final size of the particles in almost any type of degradation test, as Mr. Holowaty has stated. However, he must not lose sight of the fact that in our test the original size is uniform, since it is a piece of sinter approximately 1 cu ft in volume. If this piece drops once or twice outside the tumbler drum and then 400 times inside the drum, the final particle size will be for all practical purposes the same as if it had only experienced the 400 drops inside the drum.

4—Mr. Holowaty is right in pointing out that the use of the mean size has serious disadvantages in comparing materials that differ widely in the distribution of the weights of the various size fractions about the mean size. However, in all our experience in tumble testing sinter, we encountered no serious irregularity in particle size distribution, so that the median size of the tumble tested sinter provided a suitable measure for the sinter strength.

F — Coal

Cleaning Various Coals in a Dense-Medium Plant

by M. R. Geer, W. A. Olds, and H. F. Yancey

DISCUSSION

J. S. Huckaba (*Western Machinery Co., Spokane, Wash.*)—It has been my pleasure and privilege to be able to follow this work with the H.M.S. pilot plant very closely. This has been a very thorough and painstaking piece of work and will be of great value to the dense-media operators and manufacturers. Unfortunately time was not available to make an accurate comparison between this pilot plant and the commercial plant at Bellingham Coal Mines, both plants having Wemco drum separators.

Briefly I would like to point out what I consider the most interesting finding of this work.

Capacity: Very good results were obtained at a feed rate of 5.2 tons per hr in a 30-in. diam by 24-in. long drum separator. The maximum capacity of this drum is not known but it is something over 5.2 tons per hr for the available area of 2.08 sq ft.

Medium Preparation: The importance of proper medium preparation is well demonstrated. A "tailored" or

properly prepared medium will have the required stability and necessary differential without the need for slimes or foreign material to maintain these conditions. With a clean medium and a proper differential an efficiency of 99.9 pct is possible.

Distribution Curve: This curve is often referred to as an "error curve" or a performance curve. It is by far the most useful one available for demonstrating the operating characteristics of any type of separating equipment. Also, it gives an accurate method of determining the specific gravity of separation. I believe everyone dealing with heavy density separation would do well to study this paper, as it contains all the necessary information for plotting this distribution curve. It has been used for some time by the French, but is just now coming into common usage in the United States.

Densimeter: As accurate controls were necessary in so small a unit, a simple, cheap, and accurate specific gravity weighing device was developed. Reprints of the article on mechanization describing this densimeter are available by writing the Bureau of Mines at Seattle.

I do not quite concur with the information given therein regarding the results obtained with contaminated medium as these tests were made at a feed rate far below the demonstrated maximum. If test 43 (with contaminated medium) had been run at a feed rate of 5.2 tons per hr or greater, I am sure the results would have been very much inferior to those made with clean medium. I believe further investigations along this line would be in order before any definite conclusions can be reached.

I wish to thank Dr. Yancey for the opportunity of writing a discussion on this very informative technical paper.

Nelson L. Davis *(Nelson L. Davis Co., Chicago)*—Mr. Yancey and his associates are to be both complimented and congratulated on the constructive research into the characteristics of dense media coal cleaning as revealed in their paper.

As near as it is possible for anyone to set up small-scale laboratory testing procedure and project the results so that they can be used to anticipate those from commercial size installations, it seems to me that the report is of much practical value.

Certainly the results of this work can be authentically considered to indicate trends. However, as Mr. Yancey has pointed out, the characteristics of coal are widely variable and therefore the results of any small-scale test work are neither conclusive nor specifically dependable.

It will, therefore, be of interest to report a procedure that has been adopted and followed in Europe by the Charbonnages de France. Here seven coal cleaning plants of commercial size were installed for treating coal with dense media at capacities ranging from 100 to 480 metric tph and for feeds ranging in size from 6 to 30 mm to 30 to 250 mm. These incorporated six different types of the best dense media cleaners available. The plants were located in the Pas-de-Calais, Lorraine, Sarre, Central, and Eastern coal fields of France.

The program was initiated in 1949 and completed in 1951. During these two years intensive research and development resulted from the commercial operation of these various types of processes and it was possible to obtain facts which led to the discovery of important characteristics and comparative ratings as to the fitness of each.

From this work, the important characteristics were judged to be:

1—Efficiency with respect to the amount of misplaced float and sink material reporting with the products. In obtaining these results, unit feed capacity was initially low and gradually increased until sampling showed the efficiency of the separation was beginning to diminish.

2—By means of the above described test procedure, optimum unit feed capacities were established for each process being studied.

3—For some of the processes, it was difficult to maintain continuity of accurate density control. Therefore this became the third important characteristic necessary properly to evaluate the various types of processing equipment being tested.

4—Efficient recovery of the magnetite from the rinse slurries was found to be widely variable and, therefore, this was established as the fourth important characteristic.

In conducting this work, it was found that where the size range of the feed was, say 30 to 150 mm, all the above characteristics were better than experienced over a wider size range such as 6 to 150 mm.

During the test procedure, each size of feed was tested with each of the six processes being examined. Out of all this, the following conclusions were gained:

1—All processes showed approximately equal float-sink efficiency for the separation up to the point where optimum feed rate was reached, but such feed rates differed widely for the various processes tested.

2—Categorically, all processes naturally belong to either one of two basic types, namely, top feed vessels where the feed enters at the surface of the bath, or submerged feed vessels where the feed is submerged to a zone considerably below the surface of the bath. Materially higher capacities were gained with the latter type, particularly where more than 10 pct of the feed represented sink having a density not more than 0.10 greater than that of the bath.

3—As the average particle size of the feed material was decreased, there was a corresponding need to decrease the unit feed rate, quite evidently because the rising or settling velocity for small size near gravity material was materially less than for the larger particle sizes.

4—The ability to maintain uniformly constant bath density depended importantly, not only on the efficiency of the recovery for magnetite, but also upon the elapsed time between the point of rinsing the float and sink products and restoration of the recovered magnetite to the bath circuit. Where the elapsed time was least, the control of the bath density was best and easiest from an operating standpoint.

In conclusion, and in view of the strong trend toward the wide use of heavy media circuits for cleaning coal, it is suggested that means be established which could result in owners granting permission to U. S. Bureau of Mines' engineers to enter their heavy media plants and obtain samples of the products regularly being produced, so that in the end the comparative results could be published as case records and be made available to the coal industry. Thereby the industry would gain direct benefit from the basic facts discovered.

M. R. Geer, W. A. Olds, and **H. F. Yancey** (authors' reply)—We do not agree with Mr. Davis' statement that the results of small-scale test work are neither conclusive nor dependable. Many years of experience have demonstrated that usually laboratory-scale testing is sufficiently accurate for predicting plant performance within the limits required. Moreover, some problems are restricted by their nature to laboratory treatment, while others can be studied more quickly and cheaply in the laboratory than in the plant. Thus the laboratory or pilot plant has a definite place in coal-preparation investigations.

However, some preparation problems can be studied in the plant to much better advantage than in the laboratory; hence Mr. Davis' suggestion that a program similar to that of the French be undertaken in this country deserves serious consideration. The Bureau of Mines has made some plant-performance tests in the past, but never on a scale even approaching that of the work under way in Europe. Perhaps an increase in the tempo of research in this country is necessary, lest our own technology be overshadowed by European advances. The cooperation of coal producers, equipment manufacturers, and research groups in a coordinated, adequately-financed program could pay handsome dividends in the form of improved preparation practice.

The Blending of Western Coals for the Production of Metallurgical Coke

by John D. Price

DISCUSSION

R. W. Campbell *(Jones and Laughlin Steel Corp., Pittsburgh)*—As usual John Price has presented an excellent paper. I know of no one who has devoted more time and conscientious thought to this subject than he has, and his efforts have produced scientific data and conclusions of real value.

Results of similar studies made by the Jones and Laughlin Steel Corp. on the blending of Pennsylvania coals may be of interest.

During 1935 the late F. W. Wagner and the present writer developed an empirical physical fuel value formula for evaluating the combined physical tests of metallurgical coke, see Table IV. In the development of the formula, the tumbler test, shatter test, screen test, and porosity of coke have been taken into consideration. Each of these tests brings out some physical property not expressed by the others, and in estimation of the importance of these tests as a medium for evaluating coke for the blast furnace, their worth has been graded as follows:

Item	Pct
Tumbler, pct on 1 in.	60
Shatter, pct on 2 in.	20
Screen, pct total on 2 in.	10
Porosity, pct	10

It was thought that some additional penalty should be applied to cokes that do not show a uniform screen size, assuming that coke larger than 4 in. was not desirable and that this size was an indication of irregular size.

Therefore the screen test factor is further corrected by applying a penalty of 1 pct for each 1 pct material greater than 4-in. size as shown by the screen test.

The physical fitness of coke for blast furnace use depends upon four fundamental characteristics: 1—general strength, as indicated by the shatter test; 2—abradability, or the resistance of cell walls to reduction in size by attrition, as indicated by the tumbler test; 3—porosity; and 4—size and uniformity. Each of these characteristics is not of equal importance, but surely, in an attempt to determine an accurate physical value, the individual value of each should be taken into consideration.

The formula is used as a yardstick, so to speak, in determining variations in the normal production of metallurgical coke and in making comparisons between normal coke and experimental blends with other coals.

Table IV gives results of coking tests on raw and washed high volatile coals and these same coals with blends of coke breeze, anthracite coal, char and low volatile coals, all from Pennsylvania. The table also gives the source of the coals and coke breeze, as well as their proximate analyses.

It will be noted that the washing of the raw high volatile coal increased the physical fuel value from 26.17 to 39.16, showing the effect of removing shale and slate which produces a detrimental fracturing and weakening of the coke.

It is a well known fact that many Pennsylvania high volatile coals contain an excess of resinous material or binder which has a tendency to weaken the coke, owing to its high evolution of gases during carbonization. Tests were therefore made with coke breeze, an inert material, in an attempt to alleviate this condition. Blends of washed coal with 5 pct and 7.5 pct coke breeze collected from the coke plant quenching sump (82.9 pct through ⅛-in. screen) resulted in cokes with a physical fuel value of 20.75 and 16.73 respectively, lower than results obtained from 100 pct raw high volatile coal. It will be noted that the percentage of + 4-in. coke increased but that the tumbler test was very low. Undoubtedly better results could have been obtained if the coke breeze could have been crushed extremely fine.

During World War II the government asked the coking industry to consider the use of anthracite coal as a substitute for high quality low volatile coal, which was extremely scarce at the time. The next series of tests was made with blends of raw and washed high volatile coals and 5, 10, and 15 pct Pennsylvania No. 5 buckwheat anthracite (100 pct through ⅛-in. screen). It was necessary to use some raw high volatile coal in these blends because of insufficient washer capacity at the time. It will be noted that the physical fuel values

Table IV. Physical Coke Tests From Blends of Pennsylvania Coals

Additive →	None		Breeze		Anthracite			Char			Low Volatile			
Raw high volatile, pct	100	—	—	—	38	36	34	—	—	—	—	—	—	—
Washed high volatile, pct	—	100	95	92.5	57	54	51	90	85	80	95	90	85	80
Coke breeze, pct	—	—	5	7.5	—	—	—	—	—	—	—	—	—	—
Anthracite, pct	—	—	—	—	5	10	15	—	—	—	—	—	—	—
Char, pct	—	—	—	—	—	—	—	10	15	20	—	—	—	—
Low volatile, pct	—	—	—	—	—	—	—	—	—	—	5	10	15	20
Coke tests														
Screen, pct on 4 in.	5.8	10.5	10.7	15.5	20.0	3.35	51.7	14.1	10.2	13.7	4.8	8.8	6.8	13.0
Screen, pct total on 2 in.	56.5	72.9	58.0	63.9	80.9	89.8	91.8	76.5	78.5	80.1	71.7	72.5	73.7	76.4
Shatter, pct on 2 in.	30.8	50.5	27.3	23.9	55.2	73.6	75.7	57.6	57.7	62.2	55.4	52.3	52.4	68.3
Tumbler, pct on 1 in.	17.1	29.5	9.1	3.0	25.9	28.5	25.0	41.2	40.8	44.7	40.5	42.9	46.2	52.1
Porosity, pct	44.49	48.22	46.70	47.81	45.66	42.70	42.23	47.25	47.95	48.74	50.90	51.50	49.50	50.80
Physical fuel value	26.17	39.16	20.75	16.73	37.62	41.94	38.77	47.55	47.89	51.02	47.28	47.95	50.00	56.59

Proximate Analyses

	V.M.	F.C.	ASH	SUL.
Raw high volatile	34.39	55.89	9.72	1.20
Washed high volatile	36.10	57.66	6.24	1.06
Coke breeze	3.50	81.50	15.00	1.50
Anthracite	4.51	84.85	10.64	0.82
Char	15.54	75.55	8.91	1.82
Low volatile	18.14	74.82	7.04	0.98

Physical Fuel Value

$$P.F.V. = 0.6(A) + 0.2(B) + 0.1(C) + 0.1[(D)(100-E)]$$

Where, A = Tumbler, pct on 1 in.
B = Shatter, pct on 2 in.
C = Porosity, pct
D = Screen, pct total on 2 in.
E = Screen, pct on 4 in.

Note: Raw and washed high volatile coal from Pittsburgh seam, Washington County.
Coke breeze from quenching sump, 82.9 pct through ⅛-in. screen.
Anthracite, No. 5 buckwheat, 100 pct through ⅛-in. screen.
Char produced from Pittsburgh seam coal.
Low volatile coal from Upper Kittanning seam, Somerset County.

were 37.62, 41.94, and 38.77 respectively, and that there was a decided increase in the coke size, namely, the percent on 4 in. and total percent on 2 in., as well as the shatter test. However, there was no improvement in the tumbler test and the coke was much denser, as indicated by the porosity. A comparison of physical fuel values of blends with anthracite, char, and low volatile are as follows:

Additive	5 Pct	10 Pct	15 Pct
Anthracite	37.62	41.94	38.77
Char		47.55	47.89
Low volatile	47.28	47.95	50.00

The gradual depletion of low expanding high quality low volatile coals in Pennsylvania and West Virginia is becoming more apparent each year, and some consideration must be given to a suitable substitute for this coal when necessity demands it. The Pittsburgh Coal Co. produces a char under the trade name of *Disco* from Pittsburgh seam coal (15.54 pct volatile matter), and it was with the thought in mind that some day we might be faced with the problem of producing char as a low volatile substitute from our own high volatile coals that we obtained sufficient tonnage of this *Disco*, or char, for a series of tests. The next series of tests was made with blends of washed high volatile coal with 10, 15, and 20 pct char. A metallurgical coke of good quality was made with each blend, as the physical fuel values of 47.55, 47.89, and 51.02 indicate. A comparison of the physical fuel values of blends with char and low volatile coal are as follows:

Additive	10 Pct	15 Pct	20 Pct
Char	47.55	47.89	51.02
Low volatile	47.95	50.00	56.59

These tests seem to indicate that to obtain cokes of approximately the same physical fuel values, 5 pct more char would be required in the blend than would be necessary with low volatile coal, for example:

	Char, 15 Pct	Low Volatile, 10 Pct
P.F.V.	47.69	47.95
	Char, 20 Pct	Low Volatile, 15 Pct
P.F.V.	51.02	50.00

Two-Way Belt Conveyor Transportation

by C. W. Thompson

DISCUSSION

Paul D. Suloff *(Goodyear Tire and Rubber Co., Inc., Akron, Ohio)*—I would like first to comment on problems of the conveyor belt discussed in Mr. Thompson's excellent paper, since that is what we hope we know most about. Twists in relatively wide conveyor belt unavoidably produce a lateral maldistribution of tension, raising tension at belt edges and reducing it at the center. They also produce a lateral collapsing force on the belt at the center of the twist owing to the inherent tendency of all the longitudinal elements of the belt to try to pass through a point at the twist center. Calculation of the twist geometry by the methods shown in Mr. Thompson's paper keeps these extraordinary forces within limits which the belt designer can tolerate. No reduction in belt life due to twisting need be contemplated when this geometry is maintained. There is a minor exception that belts of extreme lateral flexibility will tend to curl laterally at the center of the twist. However, any ordinary fabric construction will perform satisfactorily in this respect.

These twists are always made in regions of low tension in the conveyor so that even in the edges of the twist, belt tension does not exceed the average tension found in highly stressed regions of the conveyor.

Offsetting these out-of-ordinary belt stresses is the advantage that Mr. Thompson has brought out of getting the return run up out of the dirt where it can be seen. This not only makes it easier to train, but also, in the event that it is not properly trained, frees it of the normal return run edge wear hazard. It is well known that return run edge wear is a prominent cause of belt mortality underground.

An interesting aspect of this two-way conveyor is that the belt may be made what is known as a *Mobius Strip*. A Mobius Strip is obtained by splicing a belt after turning one end of it 180° about its longitudinal axis. In other words, one end is turned upside down before splicing. A belt spliced in this fashion turns itself upside down every time it comes around, but the twist which has been put in the splicing, of course, stays at one location on the conveyor, in this case one of the twist sections at the end. Turning the belt over every revolution might have advantages in some cases. Belts could be made with equal covers and the two sides worn equally and simultaneously. In this case there would be no problem of getting belts on upside down by mistake. However, the two-way conveyor does not have to be a Mobius Strip. It can be twisted in such fashion that the same side is up on both runs. It is simply a question of which way the final 90° twist is made before joining the ends.

Another interesting aspect of the two-way conveyor is the problem of operating two-way conveyors in series. Here the sequencing of starting brings up some new problems. It will be recognized, although not always at first glance, that if the starting sequence is planned for one run of the conveyor the reverse will result on the other run. With the two runs carrying bulk material in both directions a reverse sequence on one run would be intolerable. In this situation the only solution appears to be a simultaneous starting of all conveyors in the series. However, with the coal in one direction and intermittent supplies in the other it would be entirely practical to sequence the conveyors for the coal run and accept a reverse sequence on the supply run.

The two-way conveyor also lends itself to new driving possibilities. First, it is quite possible to drive at the head end of each run, which of course, means a drive at each end of the two-way conveyor. Driving in this way a given belt can be extended to substantially greater lengths than a conventional conveyor with drive at one end only. In addition to this, under certain conditions the conveyor can be extended to extreme length by driving at one end and at some intermediate point on the most heavily loaded run. As a particular case, a belt carrying coal downgrade and supplies back upgrade could be extended to extreme lengths by driving at the head of the coal run and at an intermediate point of the supply run.

Mr. Thompson has been a pioneer in belt conveyor transportation underground and his accomplishment here with the first two-way conveyor of any consequence is another notable addition to the art.

H — Industrial Minerals

Titanium Dioxide Analysis of MacIntyre Ore by Specific Gravity

by Alan Stanley

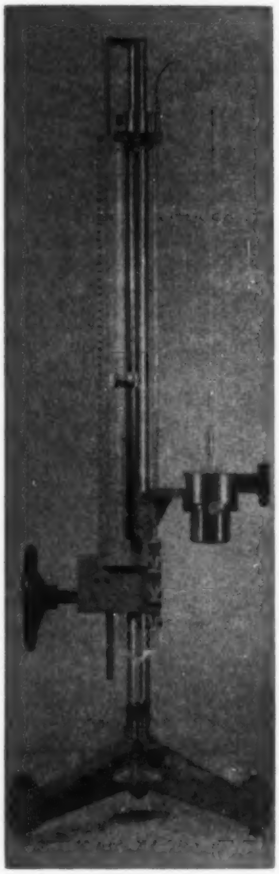


Fig. 4—The volumeter shown here is manufactured by F. Suffert-Burner A.G. in Basel, Switzerland. By means of this instrument specific gravities of test samples having a total volume of about 30 cm³ are reproducible within ±2 units in the second decimal of the specific gravity figure.

DISCUSSION

R. T. Hukki *(Finland Institute of Technology, Helsinki, Finland)*—In the analysis of mill products containing minerals of appreciable difference in specific gravity the well-known principle of the method described by Stanley is applied in a number of ways for a variety of problems. The use of Le Chatelier bottle as explained in the paper may be a dependable and sufficiently accurate way, although no information is given as to the reproducibility of the specific gravity determinations. In the case of MacIntyre ore the method is applied for three separate products produced apparently without reagents and relatively free of fine slimes. Should it be applied for flotation products carrying a substantial amount of slimes, difficulties should be anticipated in the process of eliminating air inclusions from the sample.

The difficulties mentioned above may be overcome by the use of a volumeter, an instrument designed for specific gravity determinations of finely divided solids in dry state. This instrument, see Fig. 4, is manufactured by F. Süffert-Bürner A. G. in Basel, Switzerland. Its operation is based on the law of Boyle and Mariotte. With the use of the volumeter, the specific gravities of test samples having a total volume of about 30 cm³ are easily reproducible within ±2 units in the second decimal of the specific gravity figure, and even better than that with utmost care. This accuracy is sufficient for ordinary operational control. How closely the specific gravity determinations follow the respective chemical assays depends primarily on the nature of the sample itself. In this respect no specific gravity instrument can give better results than those justified by the consistency of mineral distribution in samples analyzed.

I — Mining Geology

The Role of Geologists in the Development of The Labrador-Quebec Iron Ore Districts

by J. K. Gustafson and A. E. Moss

DISCUSSION

A. K. Snelgrove *(Michigan College of Mining and Technology, Houghton, Mich.)*—To one who was officially associated with the granting of the Newfoundland Labrador concession this paper is of special interest. In congratulating the authors, who have placed on record a valuable case history of accomplishment by the concerted effort of a large number of geologists and others, I should like to add a few side lights.

The original concession of over 20,000 square miles was negotiated in 1935 with the Newfoundland Commission of Government by J. H. Colville of Toronto for Weaver (Minerals) Ltd. This company was succeeded by the Labrador Mining and Exploration Co., Ltd., in 1936. The Geological Survey of Newfoundland, after a study of regulations governing mineral concessions throughout the British Empire, urged upon the Commission of Government that a prime condition of the concession agreement should be the conduct of the geological exploration at a scientific level comparable to that maintained by the Geological Survey of Canada under similar circumstances of accessibility. The Newfoundland Survey, then being revived, was preoccupied with an extensive program of areal and commodity surveys in the island itself; the Survey welcomed the yearly increment to the geological knowledge of a hitherto practically unknown one-fifth part of the mainland dependency as represented by the required reports of the company's operations. Naturally these reports could not be published during the selection-rejection period. Dr. Retty's achievements from these early days onward have been appropriately signalized

in the award to him of the Selwyn G. Blaylock medal by the Canadian Institute of Mining and Metallurgy in 1952.

I was privileged to inspect the progress of the field work by visits in the summers of 1937 and 1946. In talks to four AIME sections, accompanied by movies taken on these tours, I was sometimes confronted by scepticism about the possibilities of this remote iron district. It is reassuring to witness iron-ore production in sight from this new major field.

The Labrador project now ranks with the central Africa copper explorations in the employment of geologists. The contravention of a rule in the cycle of metal production that in a new territory a commodity of *low* unit value is the first fruit (e.g. Labrador's counterpart, Alaska) is attributable not only to geological vagaries but to strong capital in addition to the geological organization described in this article. Of course, the Stag Bay placer and Wabush Lake hard rock gold rushes of 1923 and 1933, respectively, stimulated interest in Labrador minerals generally, and while those incidents are best forgotten, the non-ferrous potentialities of Newfoundland Labrador, an eighteenth part of the Canadian Shield, will now be more adequately assayed with the introduction of railway transportation.

The relative effectiveness of the professional prospector and of the geologist, with their differing immediate concerns, in the discovery of mineral deposits is ever a lively topic. It would be of interest if the authors were to enumerate which of the 44 known deposits can be credited to the college boys. Furthermore, the Labrador-Quebec district since 1936 has been a valuable training ground for young geologists, and I think another significant part of the record would be the number of graduate theses which have been based on this fascinating episode of mineral exploration.

The promised detailed geological report of the staff of the Iron Ore Company of Canada is anticipated with keen interest.

L — Geophysics

Geophysical Case History, Fredericktown Lead District, Missouri

by Harold Powers, LeRoy Scharon, and Carl Tolman

DISCUSSION

Sherwin F. Kelly *(Pres., Sherwin F. Kelly Geophysical Services, Inc., Amawalk, N. Y.)*—The authors of this paper have demonstrated in an effective manner a kind of application of geophysics which is probably destined to play a role of ever-increasing importance in future prospecting campaigns. The techniques utilized for the direct detection of mineralized bodies suffer from various limitations, and where such limitations prevent successful application, the indirect attack, as exemplified in the present survey, will often prove useful. The indirect attack requires a very careful correlation of geophysical and geological data and therefore necessitates a thorough cooperation between the geologist familiar with the area and the geophysicist called in to assist in the prospecting campaign.

The authors refer to the earlier spontaneous polarization survey carried out by my firm, and a word of clarification is in order. The spontaneous polarization technique evidently did not prove as useful in tracing extensions of known ore bodies as had at first been hoped, but in fairness to the method employed attention should be drawn to qualifying statements embodied in the recommendations we submitted at that time. Statements were specifically made to the effect that individual areas of strong electrical activity *might* or *might not* correspond to commercial ore; they *would* correspond to stronger sulphide mineralization, but this would not necessarily mean the presence of ore grade. It was warned that occasional disappointment must be anticipated when drilling such areas of strong electrical activity. On this account, we believed that the most effective role for the spontaneous polarization technique would be that of searching for new mineralized areas in virgin territory. By utilization of the method on a reconnaissance basis in new territory, hitherto unsuspected mineralized zones, similar to that near Fredericktown, could easily be discovered, if they exist. I should like to emphasize this role for the spontaneous polarization method, because at the time of the Fredericktown survey we believed that this would be more useful than attempting to utilize it for locating extensions of known deposits. We suggested that such reconnaissance by the spontaneous polarization method should be conducted in conjunction with a magnetic survey for the purpose of tracing the buried porphyry ridges. Until a program such as we recommended is put into operation, it is premature to express a final conclusion as to the utility of the spontaneous polarization technique in prospecting for mineral deposits of the Fredericktown type.

The resistivity technique employed by the authors of this paper can no more indicate the presence of *ore* than can the spontaneous polarization method. Therefore any indications of sulphides which are obtained in the course of resistivity depth determinations are subject to exactly the same doubts and uncertainties as are the strong potentials, indicative of sulphides, obtained in the course of a spontaneous polarization survey. The authors admit that the method does not reveal galena mineralization directly, and I would therefore take exception to the statement in the first sentence of the next to the last paragraph, that the electrical resistivity method ". . . established the limits of the orebody south of shaft No. 1 . . ." No geophysical method now in use is capable of delimiting ore, per se. It can only establish the limits of sulphide mineralization.

It seems to me that an effective procedure for a reconnaissance survey to search for additional mineralized districts, such as that at Fredericktown, would be to apply the spontaneous polarization method first on a wide grid of observations. This would reveal any new and unsuspected zones of sulphide deposition. Such reconnaissance should then be followed by magnetic work in the same area, to determine the pattern of porphyry ridges, knobs, and troughs. Within the areas thus delimited, electrical resistivity work both by traverses as well as by depth determinations, as used by the authors, should then be conducted for obtaining more precise data relative to the porphyry-sediment contact. A detailed spontaneous polarization survey could then be utilized to reveal the zones of maximum sulphide mineralization and thereby assist in completing the picture of sulphide occurrences. By such a procedure, the most effective guidance could be given to a drilling campaign to determine where sulphides of ore grade could be anticipated.

aime NEWS

Reno H. Sales Named Jackling Lecturer for 176th Annual Meeting in New York

Reno H. Sales will be the first Daniel C. Jackling Lecturer for the Mining, Geology, and Geophysics Div. Inauguration of the lecture will take place at the Annual Meeting, February 15 to 18, at the Hotel Statler, New York City.

The lecture will be given annually by a man in mining, geology, or geophysics who has contributed significantly to the technological progress in those fields. Mr. Sales was chosen by a special committee which made its recommendation to the Board of Directors. He is chief geologist of Anaconda Mining Co., a position he has held since 1906. Born at Storm Lake, Iowa, Mr. Sales earned degrees at Montana State College and Columbia University. Among the honors he has won is the Egleston Medal presented by Columbia University.

Daniel C. Jackling, for whom the Lecture is named, is one of the outstanding figures in the development of the copper industry. He has been called the "father of porphyries" in recognition of his well-known work on the first great porphyry copper operation. He was President of the AIME in 1938.

Other developments in plans for the Annual Meeting indicate that the Mining Subdivision will present one of its most diversified programs in history. One group of papers that has been lined up includes, *White Pine Mining Operations*, *Storke Level Developments at Climax Molybdenum*, *Concrete Transportation by Pipe Underground at Cleveland-Cliffs*, and *Mechanized Mining at North Friend Station*.

A sampling of other prospective papers show that registrants can expect to hear reports on *Stress Concentration Problems in Hollow Drill Steel*, *Long Hole Surface Drilling on Colorado Plateau*, *Drilling in Northern Rhodesia*, *Undercutting with Airlegs at Butte*, *Drilling Practice in Swedish Mining*, *Drilling Hard Iron Ore*, *Sublevel Drilling at Chelan, Washington*, and *Drilling Progress at Homestake*.

Another group of papers will include *Underground Transportation at the New Allen Coal Mine of the Colorado Fuel and Iron Corp.*, *Potash Mining Methods in the Permian Basin of New Mexico*, and *General Mining Methods*.

Other papers will deal with uranium mining practices, slusher drift development, undercutting methods, and use of aluminum forms for underground concreting.

Papers will be presented by U. S. Bureau of Mines men on roof bolting and model studies in relation to roof support. A new Jersey Zinc Co. engineer is expected to report on *Relation of Pillar and Fill Support to Cycles of Mining at the Franklin Mine*.

Once again AIME members who wish to spend time under Bermuda's balmy skies can take advantage of special rates being offered to the Institute. With the fabulous facilities of the Princess Hotel—one of Bermuda's most gracious hostelries—available, members can leave New York by ship immediately after the meeting. Bermuda waters are warm enough for swimming even in February and the islands offer every summer resort sport known.

The Princess Hotel, on the right, is one of the finest hotels in Bermuda, with the city of Hamilton within easy walking distance. The yacht basin near the Princess can be seen in the foreground. Plans have been made for AIME members to travel via steamship to the islands immediately after the Annual Meeting.

Industrial Minerals Division Hails Nova Scotia Meeting as One of Greatest in Its History

by C. M. Cooley

They came, they saw, and Nova Scotia conquered them. That about sums up the total effect of the joint meeting of the Industrial Minerals Div. with the Canadian Institute of Mining and Metallurgy and the Mining Society of Nova Scotia, September 8 to 13.

The Royal Canadian Navy, the Mining Society of Nova Scotia, and the people of Nova Scotia all combined to make this one of the most memorable meetings in the annals of the division. Four men who contributed more than their share to the well-being of AIME members were: R. L. Riley, who handled transportation facilities; Allister MacDonald, in charge of general arrangements; R. M. McColl, who made registration a pleasure; Sydney Mifflen; and R. Charlick. All are members of the Mining Society of Nova Scotia.

Mr. and Mrs. S. S. Cole and son, Stephen, register with R. M. McColl at the desk at the Isle Royale Hotel in Sydney. Mr. and Mrs. C. L. Jones are in the rear, waiting their turn.

Many U. S. registrants arrived on Tuesday, a day late. They were delayed somewhat by the hurricane which swept up the East Coast. The hurricane, or what was left of it, struck Sydney, Nova Scotia, at midnight September 7, but had little effect. Monday evening's activities at the Isle Royale Hotel included an open house reception, complete with the cup that cheers.

Three field trips highlighted Tuesday morning doings. Registrants had the choice of a visit to historic Louisbourg Fortress at the southern tip of Cape Breton Island, the slag plant of Dominion Iron & Steel Ltd., or a visit to one of the submarine mines where the Dosco Miner is used.

Getting ready to take off for the drive to the Keltic Lodge are, from left to right: E. Sampson, S. Kelly, R. Charlick, F. H. Sexton, and A. H. MacKinnon.

Dr. F. H. Sexton, senior past president of the Mining Society of Nova Scotia welcomed the group to the meeting at the inaugural reception and lunch. He was followed by the Hon. A. H. MacKinnon, Nova Scotia minister of mines.

That afternoon registrants checked out of the hotel for the scenic drive to the Keltic Lodge, some 75 miles from Sydney. The lodge was meeting headquarters for the duration of the Nova Scotia meeting. Spectacular green cliffs combined with blue water to make the drive breathtaking.

Wednesday morning's technical session was attended by more than 100 persons who heard three informative papers. The session lasted until lunch. During the afternoon field trips to the quarry and plant of National Gypsum at Dingwall, or over the Cabot Trail through the Cape Breton Highlands National Park were available. However, one group of mavericks answered the call of the sea and went cruising aboard a swordfishing boat along the Cape Breton Island coast. But wherever registrants went, movie cameras whirred and shutters clicked away, as photography fans

yielded wholeheartedly to one of the most photogenic areas in North America.

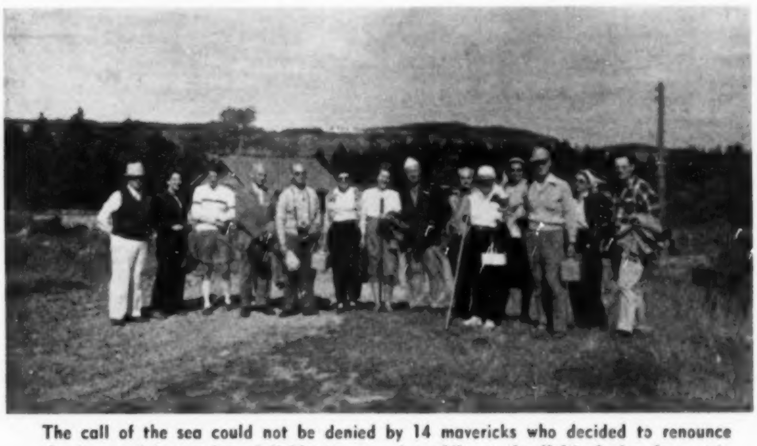
After an afternoon of exploration and discovery registrants returned to the Lodge for the social hour and dinner. Dr. D. J. MacNeil of St. Francis Xavier University and L. A. Forsyth, president of Dominion Steel & Coal Corp., addressed the diners.

Industrial minerals, fluospar, and potash were covered during Thursday morning's technical session. Papers were presented by Ian Campbell, G. F. Carr, W. L. Hill, K. D. Jacob, and Charles L. Jones. Sports contests were the order of the afternoon, with registrants vying for honors in golf, tennis, archery, darts, ping-pong, and quoits. Dr. Edward Sampson of Princeton University's Geology Dept. proved to be one of the best of the athletes. He spent almost every free daylight hour matching his golf game against the tough 7½ mile Keltic Lodge course. Industrial Minerals Div. Executive Committee held a meeting following the afternoon games.

Founders of the Clam and Eggs Society of Philadelphia get together for a bit of food and fun. They may even be eating clams and eggs. From left to right, they are: Mrs. J. Weitz, W. B. Stephenson, Mrs. R. M. Grogan, R. C. Stephenson, Mrs. W. B. Stephenson, and R. M. Grogan.

AIME members strode the decks of the *Oriole IV*, tender to the *HMCS Stadacona* on a cruise around Halifax Harbor, with Royal Navy grog issued to all hands.

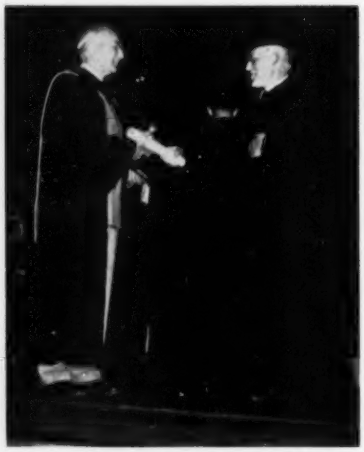
Mr. and Mrs. J. F. Joy celebrated Mrs. Joy's birthday aboard the Admiral's barge on a cruise in the Halifax harbor. Lieutenant W. Onysko, of the Royal Canadian Navy, served as host. It was a near perfect day for cruising and the Harbor offered a multitude of magnificent views as light conditions changed with the advancing day.



The call of the sea could not be denied by 14 mavericks who decided to renounce the joys and instruction of field trips one day while at the Keltic Lodge for a trip on a commercial swordfishing boat. They line up prior to going aboard.

At dinner, guests heard Prof. A. E. Flynn of the Mining Society of Nova Scotia and Andrew Fletcher, AIME President. The speakers discussed mineral resources and their importance to mankind.

Six technical papers occupied most of the formal activities on Friday. At dinner that evening prizes were presented to the winners of the previous day's sports events. The fun parade followed the dinner. One of the outstanding features of the fun parade was the First American Quartet composed of 12 AIME members, the majority of whom are members of the only chartered Clam and Eggs Society of Philadelphia. The society is dedicated, oddly enough, to the eating of clams and eggs. They did not win the contest.



Dr. H. Bannerman receives an honorary Doctor of Law degree from the Rt. Reverend Dr. P. J. Nicholson, chancellor of St. Francis Xavier University, Halifax, Nova Scotia.

Dr. Andrew Fletcher, President of the AIME, receives his degree of Doctor of Law from Rt. Reverend Dr. Nicholson during Convocation ceremonies at St. Francis Xavier.

The entire Keltic Lodge entourage went to Antigonish on Saturday for a special convocation at St. Francis Xavier University. Dr. W. A. Bell, director of the Canadian Geological Survey; Dr. Andrew Fletcher; Dr. Harold Bannerman of the U. S. Geological Survey, were awarded honorary Doctor of Law degrees. Dr. Fletcher delivered the convocation address.

A reception and dinner followed the convocation with the compliments of the Governor of Nova Scotia and St. Francis Xavier University. A. H. MacKinnon and Rt. Reverend Dr. P. J. Nicholson spoke and expressed their enthusiasm over the success of the meeting. Registrants stayed at the Lord Nelson Hotel.

Everyone unlimbered sea legs on Sunday for a sail around Halifax Harbor — compliments of the Royal Canadian Navy. Through the generosity of Rear Admiral R. E. Bidwell, RCN, Flag Officer Atlantic Coast, the 95-ft sailing yacht *Oriole IV*, tender to the HMCS *Stadacona*, and the Admiral's barge were placed at the disposal of the meeting registrants. The cruise lasted several hours. Skippering the ships were Commander E. H. Russell, Lt. Com. E. T. Coggins, and Lt. Onysko, with Royal Navy issue rum to all hands.

At the end of the sail enthusiasm ran high over the hospitality of the officers and men of the Canadian Navy. A small group of the more technically inclined passed up the sail to inspect the barites quarry of the Canadian Industrial Minerals Ltd., at Walton.

Topping the day, the Arrangements Committee of the Mining Society unveiled a lobster dinner at Hubbards Shore Club. A. H. MacKinnon presented the Order of the Good Time to all those who attended the Industrial Minerals meeting.

Indicative of the overwhelming feeling that Nova Scotia is at least one of the greatest, if not the greatest vacation and meeting place in the world, is the message of appreciation which has been issued by the Industrial Minerals Div. The same kind of feeling is expressed to the Canadian Institute of Mining and Metallurgy, Nova Scotia Minister of Mines, the Canadian Minister of Mines, the Mining Society of Nova Scotia and a host of other people and institutions who made it all possible.

President Andrew Fletcher of the AIME delivered the Convocation address before members of St. Francis Xavier faculty, students, and guests. In his speech Dr. Fletcher accented the importance of the individual and his need for a constant reaching upward toward a distant goal.

At the reception following the Convocation, AIME President Fletcher, A. H. MacKinnon, W. A. Bell, and Harold Bannerman pause to discuss the happenings of the eventful week in Nova Scotia.

A Note of Thanks —

RESOLUTION voted unanimously by the Executive Committee, Industrial Minerals Division, AIME, at a meeting held at Ingonish, Nova Scotia, Sept. 10, 1953

BE it resolved that the Industrial Minerals Division of the American Institute of Mining and Metallurgical Engineers extends to the Mining Society of Nova Scotia its sincere and enthusiastic appreciation for the Royal Welcome and genuine hospitality that has been provided at this joint meeting, and for providing thereby an opportunity to share these privileges with the congenial members of the Canadian Institute of Mining and Metallurgy.

AND be it further resolved that the Mining Society of Nova Scotia in providing so adequately for mind, body and soul — for the mind by arranging such a stimulating technical program; for the body by providing a series of sumptuous repasts of food and cheer; and for the soul by bringing us to the inspiring Nova Scotia scene and receiving us with such warm camaraderie — has made this, our first joint meeting, a most memorable occasion. We sincerely hope that there will be an early opportunity for us to reciprocate on our side of our friendly boundary.

AND be it still further resolved that copies of this resolution be sent to the secretaries of the Mining Society of Nova Scotia, the Canadian Institute of Mining and Metallurgy, and of the American Institute of Mining and Metallurgical Engineers with recommendations that it be published in their respective journals; and that copies be sent also to the Honorable, the Minister of Mines of Nova Scotia; to the Honorable, the Minister of Mines for Canada; and to his Excellency, the United States Ambassador to Canada.

AIME Board Votes On Bylaw Changes

Local Sections

At the meeting of the Board of Directors in Seattle on Sept. 22, it was voted to delete the following words from Art. XI, Sec. 3 of the AIME bylaws: ". . . only one Section shall be authorized in any one locality or district and . . ." This will permit organization of two or more Local Sections in one geographical area provided, in the opinion of the Board, they will serve a useful purpose and increase service to members.

Technical Papers

At its meeting on Sept. 22 in Seattle, the AIME Board voted approval of the proposed change in the bylaws relating to the release of technical papers. Heretofore there has been nothing in the bylaws asserting the right of the Institute to have sole publication privileges for papers presented at other than Local Section meetings. Article X of the AIME bylaws has now been amended by adding Sec. 2, which reads as follows: "All papers presented before meetings of the Institute—Annual, Regional, Branch, Divisional, and Local Section—are the property of the Institute, except those previously published elsewhere, those withheld from publication by the author, or those released by the Secretary of the Institute."

Art. XI, Sec. 3, 6th paragraph, is amended to read as follows: "Papers presented at Local Section meetings, and discussions thereon if reported, shall be the property of the Institute, except those previously published elsewhere, those withheld from publication by the author, or those released by the Secretary of the Institute."

It is the present custom to allow the publication by others of abstracts up to one third of the length of a paper presented at Mining or Metals Branch meetings, and not exceeding 300 words in the case of Petroleum Branch papers.

1954 Officers Will Be Declared Elected

No opposing candidates for nominations for AIME officers in 1954 had been received on Sept. 1, so the ticket as published in the July issues of the JOURNAL OF METALS and MINING ENGINEERING will be formally declared elected at the November meeting of the Board of Directors, as provided in the AIME bylaws. The ticket is as follows: President-Elect, H. DeWitt Smith; Vice-Presidents, T. B. Counselman and Harold Decker; Directors, the above with E. C. Babson, George D. Dub, Ralph E. Kirk, Carleton C. Long, Earl R. Marble, and Philip J. Shenon. All of these men will serve three-year terms as Director beginning next February. Another Director will be elected by the incoming Board at the February meeting, for a one-year term, to fill the unexpired term of T. B. Counselman.

WILLIAM E. WRATHER

William E. Wrather Wins Fritz Medal

William Embry Wrather, past president of the AIME and director of the U. S. Geological Survey, has been awarded the John Fritz Medal by unanimous choice of a 16-man board.

The medal is given annually for notable scientific or industrial achievement. In awarding the medal to Dr. Wrather, the board cited him as:

"A geologist of worldwide experience and fame; an outstanding scientist and historian; a wise leader distinguished for his service to the nation."

Selection of Dr. Wrather was made by a board consisting of four members each from the four founder national engineering societies: American Institute of Mining and Metallurgical Engineers; American Society of Civil Engineers; American Society of Mechanical Engineers; and American Institute of Electrical Engineers.

Dr. Wrather has been throughout the world in pursuit of geological knowledge. He has traveled the Balkans, Africa, South America, and Asia in his professional status. In 1933 he helped organize the 16th International Geological Congress in Washington. Four years later he attended the 17th Congress in Moscow.

In the past Dr. Wrather has been a member of the Texas Historical Society and once served as its president. His collection of ethnic and historical data is famous, as is his file of maps. In respect to the latter, the Library of Congress has availed itself of his collection several times when other sources were fruitless.

Mr. Wrather will receive the Fritz Medal during appropriate ceremonies now being planned for the near future.

Around the Sections

• **The Northern California Section** of the Woman's Auxiliary has been quietly seeing to it that sick and wounded veterans at the U. S. Naval Hospital, Oakland, Calif., are made a little happier. The group has contributed something like $10,000 in monthly donations to the hospital's craft shop. The Corresponding Secretary of the group received a letter from Captain J. N. C. Gordon, MC, USN, in which he said: ". . . you have been most generous to devote your time and energy to raising these funds for us. . . . I hope the hospital may look forward to your continued interest."

• Several pieces of special equipment developed specifically for lead belt mining were viewed by members of the **St. Louis Section** on a recent trip through the underground workings of the St. Joseph Lead Co., at Flat River, Mo. In addition to seeing modern weighing and dumping machines and operation of the St. Joe shovel, members took a short tour on the underground track to observe some of the special operations and the larger rooms. A trip was also taken through the Federal mill. An evening dinner meeting and discussion took place at the Masonic Temple dining room at Bonne Terre with L. L. Turley acting as toastmaster.

• **The Southeast Section** meeting at Asheville, N. C., saw some 75 members in attendance. E. L. Miller, Jr., of North Carolina State College presided. Speakers and topics at the meeting were: *Mining Practices at Tennessee Copper Co.*, H. Kendall; *Six Years of Research on Western North Carolina Minerals*, M. K. Banks; *Effects of Drought on Ground Water in North Carolina*, H. Le Grand; *Progress in Blasting and Coyote Blasting with Nitramon*, N. Johnson; *Prospecting for Diamonds in Angola, Africa*, W. Berry; and *The Expanded Milling Plant of Tungsten Mining Corporation*, J. V. Hamme.

• Theodore Page is the new chairman of the **Ajo, Ariz., Subsection.** Other officers elected were William T. Sullivan, Vice Chairman, and Bart J. Burns, Secretary-Treasurer.

• **San Juan Subsection** members spent a recent morning underground at the Idarado Mining Co., by way of the Treasury tunnel. Portal of the tunnel is on Highway 550 south of Ouray, Colo.

• **Bucyrus-Erie Co. has extended an invitation to AIME sections to see** *Digging For Your Future*, **a 16 mm, sound-color motion picture. About 75 pct of the film centers about the company's Milwaukee, Erie, Pa., and Evansville, Ind., plants. The remainder shows on-the-job views of the company's excavators, cranes, tractor equipment, and drills. Requests for the film should be addressed to Bucyrus-Erie Co., Publicity Dept., South Milwaukee, Wis.**

• William G. Caples, vice president, Inland Steel Co., spoke on *Non-Technical Problems Which Confront Engineers in Industry* at the recent Young Engineers' night of the **Chicago Section.** A field trip to several Chicago steel plants preceded the meeting at the Chicago Bar Assn. quarters, 29 South LaSalle Street.

• *The Inside Story of Thor Tools* **has been put on a 16 mm sound film in color. Factory shots are in black and white. The movie is the first from Thor's new Motion Picture Div. It has been released to branch offices in Chicago, Boston, Detroit, New York, St. Louis, and Seattle for scheduled distributor meetings. The other 16 branches will get later showings.**

MBD Proposes Amendment Allowing for Mill Design Committee

It has been announced that 18 members of the General Committee of the Minerals Beneficiation Div. voted in favor of the addition of a Unit Process Committee for Mill Design to those already in the bylaws.

A petition was submitted to all members of the General Committee of the Division in accordance with Article IX of the MBD bylaws. Three members of the General Committee voted against the move while two others did not vote.

The bylaws provide that the proposed amendment be published in MINING ENGINEERING. It must be then submitted to the membership within 60 days for a vote. If the membership approves, the amendment goes before the AIME Board of Directors for a final vote.

No member of the General Committee approving the measure offered any modification. The Proposal, dated July 22, 1953 and signed by ten members of the AIME in good standing, reads:

> The undersigned request that the General Committee of the Minerals Beneficiation Division consider the establishment of a Unit Process Committee for mill design.
>
> The most important part of any minerals beneficiation plant is its ability to operate at the lowest possible cost and to help its mine meet competition of other plants and products. One of the most important factors contributing to this is the design or physical layout of the plant to minimize the crushing and grinding, materials handling, solids-fluids separation, solution and precipitation, concentration, pyrolysis and agglomeration, and operating control problems involved in any given flow sheet and to permit the operating personnel to economically and easily maintain the facilities and provide good working conditions.
>
> Most of the basic elements of design cut across the technical fields of the various Unit Process Committees heretofore established.
>
> It is therefore proposed that this new Mill Design Committee be established to serve as a medium of interchange of information in this most important technical field.
>
> Signed by:
>
> R. M. P. Hamilton, J. W. Snavely, O. W. Walvoord, Lionel E. Booth, R. A. Groenendyke, B. A. Reak, Henry E. Kerley, Dean LaGrange, B. H. Irwin, Claude O. Dale, I. V. Korts, S. D. Michaelson, V. L. Mattson.

Spokane Section Host to President

Spokane Members of AIME were host to Mr. and Mrs. Andrew Fletcher and Mr. and Mrs. Roy O'Brien on Sept. 28 at the Ridpath Hotel. After dinner, Mr. Fletcher addressed the 112 persons who attended, and spoke about the future outlook for the Institute and the lead and zinc mining industries. The success of the party was due to the efforts of the Spokane Section of the Women's Auxiliary, Mrs. D. W. Smith and the efforts of the Vice-Chairman of the Subsection, D. Myers and the Program Chairman, M. E. Volin.

E. M. Weiss Joins Journal of Metals Staff

In September, Edwin M. Weiss was added to the staff of the JOURNAL OF METALS in New York as Assistant Editor. Mr. Weiss comes to the Institute from a short term with the U. S. Steel Corp. in Chicago. Before that he spent the better part of two years in the foreign minerals region of the U. S. Bureau of Mines. He was born in Fort Wayne, Ind., and educated at Ohio State and the University of Wisconsin. He holds a B.A. in English and chemistry, and an M.S. in economic geology.

R. W. Taylor Joins Petroleum Technology

Effective Oct. 1, Robert W. Taylor joined the staff of the JOURNAL OF PETROLEUM TECHNOLOGY in the Dallas office as Associate Editor. Mr. Taylor is a native of Brownsville, Tenn., where he was born 24 years ago. He graduated with a B.S. in chemistry, and a minor in journalism, from Murray State Teachers College, in Kentucky, in 1950, supplementing this with an M.S. in journalism from Ohio University in 1951. Since then he has been writing technical manuals and doing public relations work for the U. S. Air Force and Army.

Desmond F. Kidd to Speak at Second Mining Branch Dinner

Desmond F. Kidd, consulting mining geologist, will be the guest speaker at the Second Annual Mining Branch Dinner to be held during the 176th AIME General Meeting in New York City during February.

Mr. Kidd has been a consulting geologist since 1935. He is a graduate of the University of British Columbia, holding a Bachelor of Applied Science in Geological Engineering. He earned a Ph.D. at Princeton University after completion of graduate studies in 1933.

D. F. KIDD

While in undergraduate school he became a student assistant with the Geological Survey of Canada and by 1930 had reached the position of staff geologist. Mr. Kidd was part of the group that completed the geological exploration of the northwest coast of Hudson Bay during 1929 to 1931. Later, he investigated the Great Bear Lake Uranium deposits.

Headquarters for his consulting practice is Vancouver, B. C. Mr. Kidd joined the AIME in 1942. He is also a member of the Society of Economic Geologists and the Canadian Institute of Mining and Metallurgy. He was president of the CIM for the year 1952-53.

A registered professional engineer in British Columbia, he is also vice president and general manager of Mastodon Zinc Mines Ltd. He holds the same positions with Attwood Copper Mines Ltd. Mr. Kidd, in addition, is consulting engineer and a director of Highland-Bell Ltd., and a director of Pacific Western Airlines Ltd.

The Mining Branch Dinner last year at Los Angeles proved to be the climax of that group's Annual Meeting activities. An outstanding success in its initial staging, members of the Mining Branch who attended the affair were unanimous in their avowals to be on hand for the second edition.

New Sections Approved

Mississippi

A new Local Section in Petroleum Branch territory has been authorized. It embraces the entire state of Mississippi and will be known as the Mississippi Local Section. Its territory had previously been partly in that of the Delta Section and partly in that of the Southeast Section.

Eastern North Carolina

A Subsection of the Southeast Local Section has been approved by the Board, to be known as the Eastern North Carolina Subsection. Its area covers that part of the state east of the western boundaries of Rockingham, Guilford, Randolph, Stanley, and Union Counties. The interest of members in this area is essentially mining. Officers of the new Subsection are as follows: John V. Hamme, Chairman; Sam Broadhurst, Vice-Chairman; A. M. Szynklewski, Secretary-Treasurer.

Personals

Peter A. Champness has resigned as underground manager at Protheroe Lead Mine and is now assistant underground manager for North Kalgurli Ltd., Fimiston, Kalgoorlie, Western Australia.

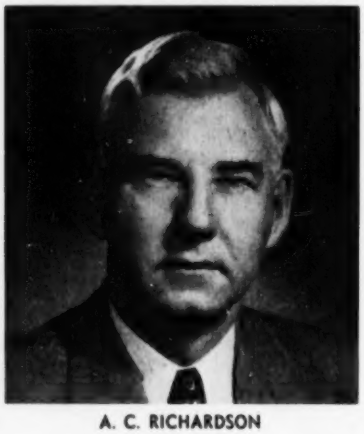
Darwin J. Pope has been transferred from Salt Lake City to the New York office of the American Smelting and Refining Co.

Rev. James B. Macelwane, dean of the Institute of Technology, St. Louis University, was recently honored at a reception in celebration of his golden jubilee as a member of the Society of Jesus.

J. J. Siegel has resigned from Kobe Inc. and has formed his own company, Tryad Service Corp., 3914 Cherry Ave., Long Beach, Calif.

Harry J. Wolf is examining mineral deposits and inspecting mining and milling operations in Brazil, where he will be engaged for several months. Before returning to New York, Mr. Wolf will visit Uruguay, Argentina, Chile, and Peru.

Evan Just, vice president of Cyprus Mines Inc., New York, has been named chairman of a steering committee on problems of nonfuel minerals for a conference to be held Dec. 2 to 4 under the sponsorship of Resources for the Future. **John W. Vanderwilt,** president of Colorado School of Mines, has been named co-chairman of this committee.



A. C. RICHARDSON

A. C. Richardson, who has had supervisory charge of research in mineral processing at Battelle Institute, Columbus, Ohio, for the past 20 years, has been named technical director. Mr. Richardson, with the Institute's other technical directors, will be responsible for the technical guidance of Battelle's $13 million per year research program for industry and the government.

Victor Phillips is preparation engineer with Industrial Engineering & Construction Co. Inc., Fairmont, W. Va. He was with Eastern Gas & Fuel Associates in Pittsburgh.

Frank A. Colbert is now with the Cerro de Pasco Corp. as mine foreman at Yauricocha, Peru.

Robert L. Wells, formerly with Anaconda Copper Mining Co., in Reno, Nev., is now with AEC in Phoenix, Ariz., as a geologist.

Gunther F. Joklik, geologist, who was with the Bureau of Mineral Resources, Canberra, Australia, is now with the geology dept. at Columbia University in New York.

LOY A. UPDEGRAFF

Loy A. Updegraff and **John W. Tieman** have joined the Columbus Staff of Bituminous Coal Research Inc.

Denys S. Lawrie has graduated from the Royal School of Mines in England and is in Northern Rhodesia with the Anglo American Corp. of South Africa Ltd. in Kitwe.

Howard H. Rice is with Neptune Gold Mining Co., Managua, Nicaragua. He was with American Smelting & Refining Co., Vanadium, N. Mex.

Elliott Northcott, II, is research engineer with International Minerals & Chemical, Mulberry, Fla. He was with McNally Pittsburg Mfg. Corp. in Kansas.

F. L. Knouse recently returned from a consulting job on the Gold Coast in Africa. Mr. Knouse is with the DMEA, Washington, D. C.

A. K. Snelgrove, head of the dept. of geological engineering, Michigan College of Mining and Technology, has accepted a Fulbright award to lecture at the University of Hong Kong, 1953 to 1954.

Werner Spross is working in Meggen, Germany, with Sachtleben AG as a mining engineer.

F. Vernon Tompkins, geologist, is with the Colombia Iron Mining Co., Cedar City, Utah.

William M. Staples is manager of construction, Chemical Construction Corp., an American Cyanamid Co. unit. Mr. Staples, a 1924 Rutgers graduate, joined Cyanamid in 1938.

Edward G. Fox, president Philadelphia & Reading Coal & Iron Co., has been named national chairman of the program committee for the 1954 Coal Convention of the American Mining Congress to be held at Cincinnati, May 3 to 5, 1954.

Clarence B. Randall, chairman of the board, Inland Steel Co., has been appointed chairman of the Foreign Economic Commission, created by the revised Reciprocal Trade Agreements Act.

H. F. Jack Kannady has opened his own office in Carlsbad, N. Mex. He is doing land surveying, mine surveying, and other types of civil and mining engineering.

A. D. Ross Fraser, president of Rome Cable Corp., **Eger V. Murphree,** president, Standard Oil Development Co., and **W. R. Elliot,** vice president, industrial relations, Jones & Laughlin Steel Corp., have been elected to the board of trustees of Industrial Hygiene Foundation, Mellon Institute, Pittsburgh. This announcement was made by the chairman of the Foundation's board, **Andrew Fletcher,** president of St. Joseph Lead Co. and president of AIME. The Foundation, only non-profit, research organization of its kind in the world, is composed of some 350 industrial companies from all parts of the U. S.

JOHN GRIFFEN

John Griffen has retired from McNally Pittsburg Mfg. Corp. where he was preparation and consulting engineer. He is now a consultant on coal preparation, both anthracite and bituminous. His address is 2523 Orlando Drive, Pittsburgh.

Donald F. Haskell, formerly with American Smelting & Refining in New York, is with Mintstone Quarries Inc., Salome, Ariz.

ELMER R. KAISER

Elmer R. Kaiser has been appointed associate director of research at Bituminous Coal Research Inc., Pittsburgh. **C. E. McGlaughlin is** now assistant to the president. Mr. Kaiser is a member of the executive committee of the Coal Div., AIME.

Felix E. Wormser, Assistant Secretary of the Interior, has been elected an alumni trustee of Columbia University. Mr. Wormser, a 1916 graduate of the Columbia School of Engineering, will serve for six years.

Earl F. Swazy is vice president of engineering, Indar Corp., Indianapolis. He was with P. R. Mallory & Co. Inc.

James R. Willett is with White's Uvalde mines, Dabney, Texas. He was with the Panama Canal Co.

Colgate Craig, Jr., has graduated from the New Mexico School of Mines and is with the Andes Copper Mining Co., Potrerillos, Chile, as a mining engineer.

ROBERT R. CARVER

Robert R. Carver has been appointed manager of a new branch office of Sprague & Henwood Inc. in Grand Junction, Colo. Mr. Carver was formerly assistant manager of the contract department at the home office at Scranton, Pa.

Eric J. Craig is resident engineer with Pluton Uranium Mines Ltd., Uranium City, Saskatchewan.

William Harris Boyer completed his undergraduate work this summer at the University of Oregon and is working as a geologist with the AEC, Grand Junction, Colo.

Charles Frederick Doerr is general manager, Great West Coal Co. Ltd., Brandon, Manitoba. He was with Western Dominion Coal Mines in Saskatchewan.

Joseph A. Mecia, recently in the U.S. purchasing equipment and conferring with Utah Construction Co. officials, is back in Korea. He is coordinator for Utah Construction Co. which is working for the Korean government under a management-type contract for modernization of prewar operations.

EARL C. KIRK

Earl C. Kirk has been appointed carbonization engineer for the Pocahontas Fuel Co. Inc. His headquarters will be in Cleveland and he will specialize in sales and service to byproduct coke plants.

Philip B. Eng, who was with American Cyanamid Co. in Stamford, Conn., is with the Chemical Construction Corp. in New York City.

J. M. Rose has graduated from Melbourne University with the degree of B.M.E. and is a cadet engineer with the Zinc Corp. at Broken Hill, N.S.W., Australia.

Erwin C. Winterhalder is with the AEC in Denver as a geologist.

Douglas C. Brockie is now senior geologist with Tri-State mines, mining & smelting div., The Eagle-Picher Co., Cardin, Okla.

Walter F. Camacho is with The Eimco Corp., export dept., New York City.

J. M. Elias, formerly with the Mineral Deposits Branch, USGS, is in the engineering dept., Anaconda Copper Mining Co., Butte, Mont.

THOMAS M. WARE

Thomas M. Ware, vice president in charge of the engineering div., International Minerals & Chemical Corp., Chicago, has been elected a director of Dunlap & Associates Inc., Stamford, Conn. A graduate of Cornell University, Mr. Ware has been design engineer for Lockheed Aircraft Corp., chief engineer of the Radioplane Co. of Van Nuys, Calif., project engineer of the Special Devices Div. of the Office of Naval Research, and staff engineer for George Fry & Associates.

Robert D. MacAfee, who was with the Army in Japan, is now an active partner with MacAfee & Co., consulting mining engineers, in the James Oviatt Bldg., Los Angeles.

Robert E. Mead has been appointed assistant plant superintendent, New York Trap Rock Corp., Clinton Point Plant, New Hamburg, N. Y. He had been in the engineering dept. since 1946.

Ernest N. Patty has taken over his new duties as president of the University of Alaska. Mr. Patty is president and general manager, Alluvial Golds Inc.

Charles Meyer is now professor of geology at the University of California, Berkeley. He was with Anaconda Copper Mining Co., Butte, Mont.

R. D. Wendeborn is the Newfoundland representative for Canadian Ingersoll-Rand Co. Ltd. His headquarters will be in St. John's.

Grover E. LeVeque has retired as manager of the Minnesota Ore Div., Jones & Laughlin Steel Corp. He will be retained in a consulting capacity. **Harry F. Kullberg,** general superintendent, succeeds Mr. LeVeque as manager.

Thomas Midgley, III, who was an application engineer with Allis-Chalmers Mfg. Co., West Allis, Wis., is now a project engineer with Kaiser Engineers, Oakland, Calif.

Obituaries

Appreciation of
Kenneth C. Browne
by C. V. O. Hughes

Kenneth C. Browne (Member 1915) died suddenly on July 10 in a Lakeland, Fla., hospital. At the time of his death, he was chief engineer of the Florida dept. of Virginia-Carolina Chemical Corp.'s Phosphate Mining Div.

Mr. Browne was born and educated in New York City, receiving his E.M. degree from Columbia University School of Mines in 1910. He was a member of Sigma Xi, Theta Delta Chi, the Columbia University Club, and the National Society of Professional Engineers.

He went to work for the St. Lawrence Pyrites Co. in upper New York State in 1910, and later became superintendent of operations. In 1914, he went to Copper Cliff, Ont. as a mining engineer for International Nickel Co. He worked for International Nickel in Canada until 1922, serving in various capacities in their operations.

He first entered the Florida phosphate field in 1923, as general manager for the Phosphate Mining Co., and remained in that capacity until 1926, when he returned to New York as senior assistant engineer, Bureau of Engineering, City of Yonkers. He rejoined the Phosphate Mining Co. in 1943, as mining engineer in the New York office. After Virginia-Carolina Chemical Corp. bought out Phosphate Mining Co. in 1945 Mr. Browne moved to Florida as chief engineer of the Florida dept.

K. C. Browne was actively engaged in the construction of large new processing facilities for Virginia-Carolina Chemical Corp. at the time of his death. His sudden loss was a shock to the many friends and associates who had come to know him not only as a fine and highly capable engineer, but as an unfailingly cheerful and unselfishly helpful friend, and tireless coworker. He is survived by his wife. Funeral services were conducted in Lakeland, and his body was returned to New York to be buried in Kensico Cemetery in Valhalla.

Appreciation of
Charles D. Kerr
by W. G. Pearsall

Charles D. Kerr (Member 1952), Hibbing, Minn. died June 5, 1953. Mr. Kerr was superintendent of the iron ore interests of the Mesabi Mineral Assn. on the Mesabi Range. He was born in St. Paul, Dec. 23, 1890, and graduated from the University of Minnesota as a mining engineer in 1915. Thereafter he was connected with the iron ore industry in Minnesota, except during World War I, when he served a year in France with the army engineer corps. In 1931 he joined the Mesabi Mineral Assn. as an engineer and later was promoted to superintendent. He was well known in civic as well as engineering circles, and he took a keen interest in hunting and fishing. He is survived by his wife, a daughter, and four grandchildren. His son, Charles D. Kerr, Jr., was a captain in the U.S. Air Force and lost his life in a plane crash in 1947.

Appreciation of
Paul B. Lord
by R. F. Goodwin

Paul B. Lord, a member of AIME since 1920, passed away suddenly in Boston, on Aug. 9, 1953. Born in Haverhill, Mass., May 2, 1888, and educated at Massachusetts Institute of Technology, he retained his affection for New England even though his active business life was spent in Mexico and in the Southwest. He had looked forward to spending his years after retirement at his home, "Quiet Meadow," in Orleans, Cape Cod, where he had enjoyed many of his vacations.

After graduation from MIT with the degree of S.B. in mining engineering with the Class of 1909, he entered the employ of American Securities Co. as assistant engineer at Velardena, Durango, Mexico. With the exception of the period of revolutionary disturbances, his entire professional career was spent in Mexico with American Smelting and Refining Co. or one of its subsidiary companies. In July 1946 he became general manager of its Mexican mining dept. with headquarters at El Paso, Texas. He remained in this post until he retired in May 1953.

Paul Lord was an outstanding engineer and business executive with a most comprehensive knowledge of all phases of mining operations in Mexico. He was a skilled negotiator and through long experience became expert in handling complicated labor problems throughout Mexico. He was an able administrator, loyal to his employer and his employees, a true friend and a good companion. In his passing his many friends and business associates have experienced a personal loss. Those in the mining engineering profession can be proud that Paul Lord was one of them.

Karl R. Paykull (Member 1942) died in Seattle, June 18, 1953 as the result of a stroke. Born in Marstrand, Sweden, July 24, 1874, he belonged to the baronial family, Paykull. He studied at the University of Upsala and afterwards worked as an apprentice at a cannon factory in Sweden. Mr. Paykull visited the U. S. in 1900 and returned five years later to prospect in California. He also prospected in Alaska and was with the Alaska Treadwell Gold Mining Co. He settled in Seattle in 1927 where he was engaged in consulting and research work on manganese and coal carbonization.

Appreciation of
Robert Waskey
by Alan Probert

On Saturday, Aug. 1, 1953, Robert Waskey (Member 1935) died suddenly of coronary thrombosis at the age of 46, at his home in Washington, D. C. Since graduation from the University of Washington in 1930, Bob Waskey's activities as a mining engineer took him to many lands, from Alaska and continental U. S., to Latin America and Africa. Two years ago he left Alaska to contribute his technical competence to the government for the duration of the emergency, as he had done during World War II. At the time of his death he was employed in the domestic expansion div. of Uncle Sam's mineral procurement organization, DMPA, where he was concerned with the nonmetallic raw minerals needed for the defense effort.

Wherever Bob has lived he has left a host of true friends who will sincerely mourn his death, from Nome, Fairbanks, and elsewhere in Alaska, Brazil, and Colombia, from Washington, D. C., to the Congo. A man of integrity, he was loyal to his employers and had the ability to think for himself whether personally evaluating a mineral deposit or ap-

praising a report submitted by other engineers. He had broad experience in placer mining and was well known both as an exploration and operational engineer throughout Alaska and the Yukon; he spent several years at the gold and platinum bearing deposits of Colombia and investigated the tin placers of central Africa for FEA during the war.

His birthplace was Washington, D. C., where the family lived at the time his father, Frank H. Waskey, was the first congressional delegate at large for the Territory of Alaska. He spent his childhood in Nome and was educated in American public schools and the University of Washington. He is survived by his wife and daughter, Chloris I. Waskey and Patricia I. Waskey, of Washington, his father, of Dillingham, Alaska, a brother, John B. Waskey, of Glendale, Calif., and his well-loved and much respected stepfather, Captain Ralph W. Newcomb, of Seattle, retired after 53 years from the Yukon River steamboat service. The mineral industry has lost a dependable, steadfast engineer with the death of Bob Waskey—a loss it can ill afford.

Specific assignments in the professional field followed several years of experience gained in jobs as miner and mill hand, assayer, flotation operator, and dredge panner. He was employed by the U. S. Smelting Refining & Mining Co. in Nome, Alaska, during the 1933 season and the following year as prospect foreman in Fairbanks. For the next four years, he was in the Republic of Colombia, first of all with the South American Gold & Platinum Co. and later as engineer and director of operations for Colombian Placers, S. A. A period of employment with the Walter Johnson Engineering Co. included scouting and examination of mining properties in Colombia, Nevada, and California, which continued until 1943 when he joined the Foreign Economic Administration of the U. S. Government. This work, under Allan Bateman, included the investigation of deposits of strategic minerals in Brazil, including quartz crystal, mica, beryl, tin, tantalite, as part of the procurement program during the war. The principal fields of activity while he was with FEA were Brazil and the Congo.

The war over, Bob Waskey spent a field season in Yukon Territory in charge of examination of prospecting of gold placer deposits for Yukon Alluvial Gold Ltd. From there, he returned to the U. S. Smelting Refining & Mining Co. in Fairbanks until joining the DMPA in 1951.

Charles G. Williams (Member 1939) died Aug. 14, 1953 at the Bracebridge Memorial Hospital in Ontario as the result of a stroke. A well-known Canadian mining engineering and consultant, Mr. Williams was professor of mining and head of the department at the University of Toronto from 1939 to 1948. He was born in London, Ont., in 1882, and graduated with honors from the University of Toronto in 1905 with a B.A.Sc. The next two years he supervised the installation of special mill processes and machinery. He then worked as a mill shift boss at the Buffalo mine, Cobalt; as superintendent of the Otisse silver mine at Elk Lake, and as superintendent of the Nova Scotia mine in Cobalt. From 1911 to 1912 he was general manager for the Deister Machine Co., Fort Wayne, Ind. In 1913, shortly after the opening up of the Porcupine Gold Field, Mr. Williams joined the staff of Hollinger Consolidated Gold Mines Ltd. at Timmins as a mill draftsman. Three years later he was general manager of all operations. From 1928 to 1939, with the exception of two years as general secretary of the Canadian Metal Mining Assn., 1934 to 1936, he was a consulting engineer in Toronto. Following his years at the university, he returned to private practice, and as a director of Eldorado Mining & Refining Ltd., Mr. Williams was particularly active and interested in the development of Canada's important pitchblende deposits at Great Bear Lake, N.W.T., and at Beaverlodge, Saskatchewan. He was also director of Tech-Hughes Gold Mines Ltd., and its subsidiary Lamaque Gold Mines Ltd., and of Coniagas Mines Ltd.

Frederick E. Wright (Member 1904) former petrologist at Carnegie Institution, died on Aug. 25. He was secretary of the National Academy of Sciences and staff petrologist from 1906 until his retirement in 1944, of the geophysical laboratory of the Carnegie Institution of Washington. Dr. Wright was born in Marquette, Mich. He received a Ph.D. from Heidelberg University. He was then an instructor at the Michigan College of Mines. From 1906 to 1917 he was a geologist for the U. S. Geological Survey. Dr. Wright received an honorary doctorate in science from the University of Michigan in 1940. During World War I he was a major in Army Ordnance and later served in a civilian capacity with the Office of Science Research and Development.

NECROLOGY

Date Elected	Name	Date of Death
1903	Galen H. Clevenger	Aug. 2, 1953
1916	John Davenport	Apr. 4, 1953
1944	Harry J. Evans	June 1, 1953
1920	C. S. T. Farish	Aug. 29, 1953
1904	H. P. Henderson	Sept. 10, 1953
1925	John M. Jennings	Mar. 5, 1953
1946	A. R. Llewellyn	May 14, 1953
1940	Ralph B. Lloyd	Sept. 9, 1953
1919	A. E. MacArthur	Aug. 16, 1953
1888	T. A. Rickard	Aug. 15, 1953
1936	S. C. Sandusky	July 24, 1953
1916	Louis A. Scholl, Jr.	Sept. 22, 1953
1917	William Huff Wagner	Aug. 31, 1953
1902	L. Webster Wickes	Sept. 16, 1953

Proposed for Membership
MINING BRANCH, AIME

Total AIME membership on September 30, 1953 was 19,401; in addition 1748 Student Associates were enrolled.

ADMISSIONS COMMITTEE

O. B. J. Fraser, Chairman; Philip D. Wilson, Vice-Chairman; F. A. Ayer, A. C. Brinker, R. H. Dickson, Max Gensamer, Ivan A. Given, Fred W. Hanson, T. D. Jones, George N. Lutjen, E. A. Prentis, Sidney Rolle, John T. Sherman, Frank T. Sisco, R. L. Ziegfeld.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

California
Los Angeles—Obert, Lawrence R. (A)
Pasadena—Holman, Joseph R. (A)

Colorado
Golden—Wagner, Warren R. (R. C/S—J-M)
Grand Junction—Munro, John T. (M)
Uravan—Seidel, Don C. (J)

Connecticut
Noank—Buettner, Melvin A. (R. C/S—S-J)
Stamford—Schenck, George H. (R. C/S—S-J)

Idaho
Wallace—Eakins, Gilbert R. (R. C/S—S-J)

Massachusetts
Newton Centre—Goodwin, David M. (A)

Michigan
Negaunee—Violetta, Donald C. (R. C/S—S-J)

Minnesota
Hibbing—Madsen, J. M. (M)

Missouri
Bonne Terre—Winkel, Marvin F. (R. C/S—S-J)

Montana
Anaconda—Dimock, Everett P. (M)

Nevada
Reno—McGirk, Lon S., Jr. (R. C/S—S-A) (M)

New Jersey
Princeton—Frantz, Samuel G. (M)

New Mexico
Carlsbad—Waltman, Reid M. (M)

New York
Balmat—Lane, Marvin E. (R. C/S—S-M)
Bronxville—Hernandez, Clinton N. (M)

North Carolina
Spruce Pine—Dent, Raymond T. (M)

Oklahoma
Cardin—Kuklis, Andrew (A)

Pennsylvania
Center Valley—Lanning, Mayo W. (R. C/S—J-M)
Chambersburg—Berman, Fred J. (J)

Utah
Magna—Twitchell, Lafayettte J. (R. C/S—S-M)
Salt Lake City—Coleman, Robert B. (R. C/S—S-J)

Virginia
Marion—Riddell, Paul A. (R. C/S—S-J)

Argentina
Buenos Aires—Perichon, Luis A. (J)
San Juan—Leidhold, Helmut (J)

Brasil
Minas Gerais—Archibald, Charles W. (M)

Canada
Falconbridge, Ont.—Sheppard, Rodney T. (J)
Montreal, Que.—Gillespie, Albert G. (M)
Ottawa, Ont.—Brown, Ernest A. (M)

England
Camborne, Cornwall—Lenten, Clifford F. (A)
Ipswich, Suffolk—Kerr-Cross, David (M)

Mexico
Estacion Wadley, S.L.P.—Whitman, Judson H.—(R. C/S—S-A) (M)
Taxco, Gro.—McKinley, Derwood A. (J)

Peru
Lima—Arias P. de L., Agustin (R. C/S—A-M)
Lima—Tasaico, Narciso O. (M)

N. Rhodesia
Mufulira—Young, David (M)

Transvaal, S. A.
P. O. Van Dyksdrif—Lorimer, William W. S. (M)

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Oliver Building — Pittsburgh, Pa.

Coming Events

Nov. 6, AIME, National Open Hearth Steel Committee, Pittsburgh Section, William Penn Hotel, Pittsburgh.

Nov. 6-7, Annual Fall Meeting of the Central Appalachian Section, AIME. To be held jointly with the West Virginia Coal Mining Institute at The Greenbrier, White Sulphur Springs, W. Va.

Nov. 11, AIME, Connecticut Section, Hammond Metallurgical Laboratory, Yale University, New Haven.

Nov. 11, AIME, National Open Hearth Steel Committee, Western Section, Rodger Young Auditorium, Los Angeles.

Nov. 13, AIME, St. Louis Section, Coal Meeting, York Hotel, St. Louis.

Nov. 17, American Fair Trade Council, open forum, Hotel Roosevelt, New York.

Nov. 23-24, Operations Research Society of America, Statler Hotel, Boston.

Nov. 29-Dec. 4, ASME, Annual Meeting, Statler Hotel, New York.

Nov. 30-Dec. 5, Exposition of Chemical Industries, Commercial Museum and Convention Hall, Philadelphia.

Dec. 1-4, National Assn. of Corrosion Engineers, conference, University of Oklahoma.

Dec. 2, AIME, Chicago Local Section, Chicago.

Dec. 2-4, Electric Furnace Steel Conference, Netherland Plaza Hotel, Cincinnati.

Dec. 2-4, Mid-Century Conference on Resources for the Future, Washington, D. C.

Dec. 11, AIME, St. Louis Section, York Hotel, St. Louis.

Dec. 13-16, American Institute of Chemical Engineers, Annual Meeting, Hotel Jefferson, St. Louis.

Dec. 27, Conference on Scientific Editorial Problems, AAAS, Boston.

Dec. 28-29, Annual Chemical Engineering Symposium, University of Michigan, Ann Arbor.

Jan. 6, 1954, AIME, Chicago Local Section, Chicago.

Jan. 12-14, National Constructors Assn., Annual Meeting, Hotel Commodore, New York.

Jan. 13, AIME, Connecticut Local Section, American Brass Co., Torrington, Conn.

Jan. 20, AIME National Open Hearth Steel Committee, Western Section, Rodger Young Auditorium, Los Angeles.

Jan. 25-27, Plant Maintenance & Engineering Conference, Hotel Conrad Hilton, Chicago.

Jan. 25-28, Plant Maintenance & Engineering Show, International Amphitheatre, Chicago.

Feb. 15-18, AIME, Annual Meeting, Mining and Petroleum Branches, Hotel Statler; Metals Branch, Hotel McAlpin, New York.

Mar. 8-10, American Institute of Chemical Engineers, Statler Hotel, Washington, D. C.

Mar. 10, AIME, Connecticut Local Section, American Brass Co., Torrington, Conn.

Mar. 17, AIME, National Open Hearth Steel Committee, Western Section, Rodger Young Auditorium, Los Angeles.

Apr. 5-7, AIME, Blast Furnace, Coke Oven, Raw Materials, and National Open Hearth Conference, Palmer House, Chicago.

Apr. 26-30, American Society of Tool Engineers' Industrial Exposition, Convention Center, Philadelphia.

Apr. 27, Open Meeting of the Assn. of Consulting Chemists and Chemical Engineers Inc., Hotel Belmont Plaza, New York.

May 3-5, Coal Convention of the American Mining Congress, Cincinnati.

May 3-8, International Conference on Complete Gasification of Coal, Inichar, Liége, Belgium.

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